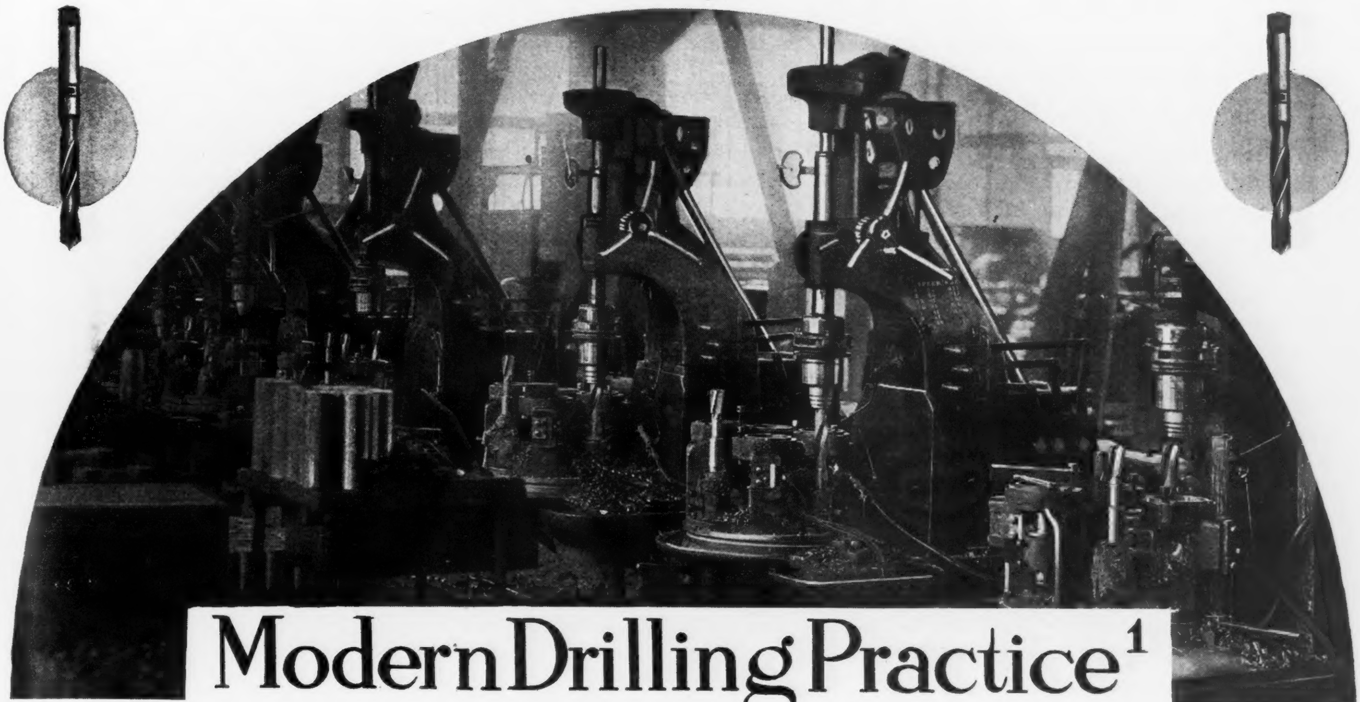
JANUARY MACHINERY 1918



Modern Drilling Practice[1]

by Edward K. Hammond[2]

Many users of drilling machines fail to appreciate the full possibilities of this type of machine tool; and it is probably safe to say that the average user of drilling machines gives more thought to planning methods for the operation of practically every other type of mechanical equipment used in his factory. In this series of articles it is the intention to explain the basic principles which must be observed in designing jigs and work-holding fixtures, handling the work, selecting suitable speeds and feeds, grinding drills, etc., in order to secure the maximum efficiency in performing drilling operations. The examples of shop practice that are illustrated and described have been selected with the view of showing the great improvement in average results that could be obtained on the different types of drilling machines if they were always operated under favorable conditions. In every case the machines selected for the purpose of illustration have been chosen because the work performed on them is representative of modern factory practice and not because the machines themselves are superior to other machines of similar type which are built in this country.

In those shops where the most remarkable improvement has been made in rates of production secured on drilling machines, the increase has been largely due to constantly higher speeds and rates of feed which are employed in the performance of drilling operations, but more particularly as a result of increasing the speed. There are many noteworthy advantages secured through drilling at high speed, and these will receive detailed consideration in a later section of this article. The remarkable increases in the speed at which drilling operations are performed has created a condition which was formerly unimportant, *i. e.*, in regard to the relation between the time actually consumed in the performance of a drilling operation and the time required for setting up the work. Obviously, increasing the speed and rate of feed cuts down the time required to drill a hole, and so jigs and work-holding fixtures must be so constructed that the setting-up time does not become the limiting factor in performing the drilling operation. The steps which must be taken to secure this result will vary according to the depth of the hole, and consequently according to the time required to complete the drilling operation. In any case, the two chief points which require consideration are to design jigs and fixtures with clamping devices which may be quickly operated, so that the minimum amount of time is required to secure the work in place ready to be drilled, or to provide jigs or fixtures of the so-called indexing type, so that the operator may be setting up a piece in the fixture while the machine is engaged in drilling work held in other sections of the fixture. This point will receive detailed consideration in connection with a description of examples of drilling machine equipment which will be illustrated and described.

Object of Using Drilling Jigs and Fixtures

A jig or work-holding fixture may be used on a drilling machine to provide for interchangeability of the drilled pieces, or it may be used for the sole purpose of holding the work and preventing it from turning while the drilling operation is being performed. By far the most important object of using a jig or fixture for drilling parts that are to be assembled together is to provide for accurately locating holes in all duplicate parts produced on the drilling machine, so that bolts, screws, etc., will enter holes in all of these parts without the necessity of subsequent hand fitting. Obviously, the use of jigs and fixtures provides means of greatly reducing the ultimate cost of producing such parts. A further economy is secured through their use, owing to the fact that both the jig or fixture and the drilling machine can be made so simple to operate that unskilled labor may be employed with assurance that the work will possess the desired degree of accuracy. Aside from the actual saving in the cost of performing drilling operations, it is obvious that an even greater saving will usually be effected through the production of interchangeable parts which may be sent directly to the assembling department, where they are ready to be assembled into the finished product without requiring any hand work. Still another claim in favor of the use of jigs and fixtures is that the production of interchangeable parts makes it a very simple matter for broken pieces to be replaced, with perfect assurance that such pieces will fit properly when received by the customer.

In practically all up-to-date manufacturing establishments interchangeable manufacture is now in vogue, and one of the great advantages of this system is that where a complete equipment of jigs and fixtures is employed for the performance of all machining operations, work may continue on the production of all different parts of the product, which are machined in different departments of the factory, with assurance that these parts will assemble together properly. This saves the necessity of waiting for one part to be finished so that other parts may be fitted to it, as was the case under the old method

[1] For previous articles on drilling practice, see "Doing Lathe Work on All-geared Drills," May, 1915; "Drilling Cotter-pin Holes," April, 1915; "How the Chisel Point of a Drill Wears," March, 1915; "A Speed Record in Drilling," December, 1914; "Cutting Speeds and Feeds for Twist Drills," May, 1912; "Twist Drill Grinding," June, 1909; "Experiments on Twist Drills," May, 1909, and June, 1909; "Drilling Adding Machine Side Frames by Plate Method," September, 1910; "Minimizing the Time of Drilling Operations," July, 1909, and August, 1909; "Data on High-speed Drilling," May, 1909; "Deep Drilling," January, 1904; "Deep Hole Drilling in Gun Construction," May, 1902; and "Deep Hole Drilling," December, 1901.

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of "building" a machine, which stands out in strong contradistinction to the modern methods of "manufacturing" which are now employed. Necessarily, the attainment of this result calls for the use of a set of jigs and fixtures which have been very carefully designed so that the relation of all machined holes and surfaces are not only accurate in a given piece, but are also accurate in relation to each other.

Definition of Terms "Jig" and "Fixture"

The terms "jig" and "fixture" are loosely used as if they could be properly applied to the same class of equipment, although this is not the case. Jigs and fixtures are made in such a great variety of types that it is hard to cover the subject comprehensively without going into a great deal of detail. Probably the best general distinction to make is that a jig is furnished with hardened steel bushings, through which the drills are guided into the work, while in the case of a fixture the desired location is secured through the provision of gage points on the fixture or by some other means. A combination of gage points and bushings is often employed in working out the design of a jig. In both jigs and fixtures, provision is commonly made for holding the work to prevent it from turning, although there are special cases where jigs are clamped to the work or dropped over a machined surface which affords the desired location for the jig. In the majority of cases, however, both jigs and fixtures are furnished with means of securing them to the table of the drilling machine, common methods of obtaining this result being to provide a tongue on the bottom of the fixture which enters a T-slot in the table, or to employ some similar method.

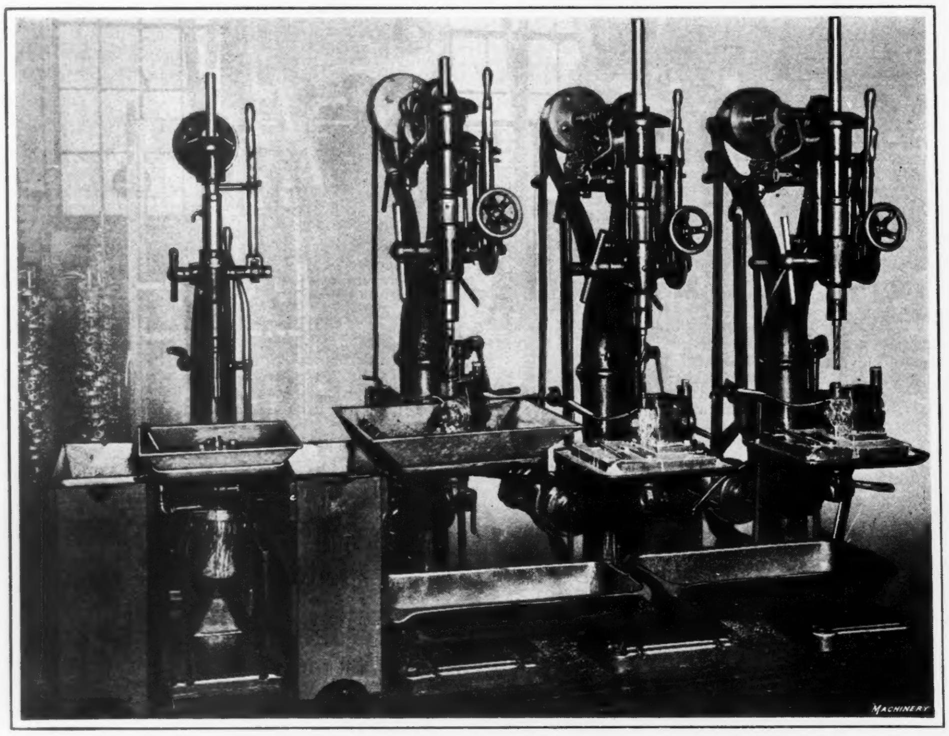

Fig. 1. Vertical Drilling Machines built by the Rockford Drilling Machine Co., equipped with Indexing Fixtures for drilling Universal Joint Rings

In working out the design of either jigs or fixtures, there are a number of points which must receive careful consideration if the most satisfactory results are to be obtained. Among these there is none of greater importance than to be sure that the design of clamping devices which are furnished to secure the work in place, and the form of the fixture, are both such that the work may be put in and taken out after the drilling operation has been completed without entailing an unnecessary loss of time. This point has assumed exceptional importance on account of the steadily increasing rates of speed and feed employed in the performance of drilling operations, because the consequent reduction in drilling time means that the ratio of setting-up time to drilling time will become constantly less favorable unless great care is taken to eliminate all unnecessary loss in setting up the work. Generally speaking, it is necessary to provide a jig or fixture for use in drilling the hole in a part which is to be assembled with a second part that has been drilled with the use of similar equipment. There are certain cases, however, where this is not advisable, as it may be impossible to properly locate a jig on one of the parts to be drilled, or if the attempt were made to design a jig, it would be so complicated as to prove impractical. In such cases the part drilled in a jig is used as the jig for drilling the second part on which it is to be assembled, and where this method is followed, satisfactory results are secured, although the production time is likely to appear somewhat high.

One of the most important questions that should be decided before making a jig is the amount of money that can be profitably spent on special tools for the operation under consideration. In many cases greater efficiency could be secured by making a complicated and expensive tool, but this additional investment would not be warranted by the slight saving in production cost that would be effected through its use. In all cases where the question of jig and fixture design comes up, a careful comparison should be made of the cost of drilling under the present method and the estimated cost of performing the same operation in the new jig or fixture; and unless the saving is sufficient to warrant adoption of the new method, it is obvious that further work should be done by the tool designer to see if a greater reduction in production cost is not possible. While discussing the question of cost, attention is called to the fairly obvious fact that the number of parts to be machined will determine the expenditure that is warranted for jigs and fixtures, as it would be obviously impractical to spend a lot of money for special work-holding equipment — regardless of the efficient results that could be secured through its use —unless the number of parts to be drilled were great enough to return a satisfactory income on the tool investment.

Selection of Locating Points

In choosing the locating surface of gage points on the work to be drilled, consideration must be given to the facilities for locating the corresponding part with which it is to be assembled. This is a highly important point, because, although jigs may be alike as far as their provision for locating the holes is concerned, there may be no facility for locating holes in the corresponding part in the same manner that was used in the one for which a satisfactory selection of locating points was made. In such cases, while the drilled holes may coincide, other surfaces which are required to come into coincidence may be considerably out of line. Therefore, one of the main principles of location is to have the two component parts located from corresponding points or surfaces on the castings. This naturally draws attention to the importance of designing patterns for use in the foundry with suitable provision for holding the castings while they are being drilled. It is sometimes apparent that lack of cooperation between the drafting-room and machine shop, which results in failure to provide efficient means for holding the work, is responsible for adding greatly to the cost of performing machining operations.

Wherever it is possible, special arrangements should be made in designing jigs and fixtures so that it is impossible to insert the piece in any but the correct way. This is especially important in developing tools for use in those shops where a great deal of unskilled labor is employed, as care taken by the tool designers will often be the means of saving a great deal of money which would be lost through spoiling

work. The use of fool-proof jigs and fixtures in which it is impossible to insert the work upside down, etc., will also be the means of making important savings in plants where the labor is fairly well trained in the performance of the different classes of work, but where the use of a piece-work system may be responsible for some slight carelessness on the part of machine operators. Another important point is that where the work may vary in size, as in the case of rough castings, etc., it is necessary to have at least some of the locating points made adjustable and placed so that they can be easily reached to make the necessary adjustment, and then fastened so that they are reasonably positive in their function of locating the work.

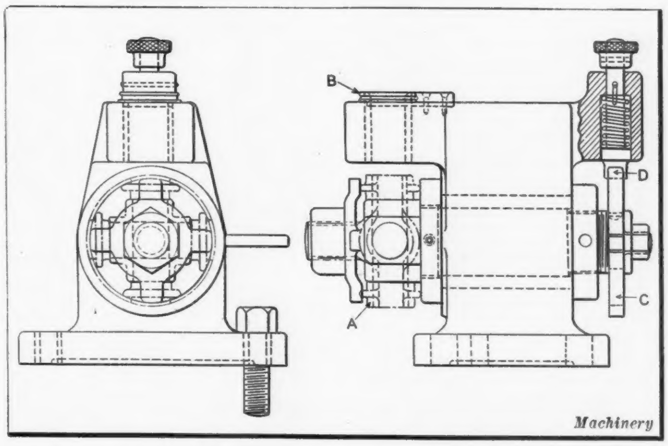

Fig. 2. Indexing Fixture used on Drilling Machine shown in Fig. 1 for drilling Four Holes in Universal Joint Rings

Clamping Devices

In designing clamping devices, care should be taken to arrange each clamp so that the direction in which the strain of the tool or cutter acts upon the work is such that the clamp will possess the maximum strength to resist the pressure of the cut. Another important point is to design the clamps so that they may not readily be detached from the fixture and require a lot of time to be spent in finding clamps which have been mislaid. In all cases, clamping devices should be made as simple as possible and they should be made to operate quickly for reasons that have already been mentioned. In addition to designing clamps so that they are strong enough to resist the pressure of the cut, it is highly important to see that such pressure will not result in springing the work out of place and cause inaccuracy in the location of holes and machined surfaces. This point can best be taken care of by paying attention to the selection of locating and bearing points for the work and clamps, respectively, so that the probability of springing the work is reduced as far as possible. One point to observe in providing for rigidity is to locate clamps or straps so that they are exactly opposite some bearing point on the surface of the work, whenever such a location is found feasible. Another point of importance, in so far as it may affect the accuracy of work produced in a jig or fixture, is to work out the design in such a way that chips may be readily cleared out of the fixture to avoid danger of inaccuracy resulting from chips accumulating on the locating points.

Jigs and fixtures should be made as light as possible in order that they may be easily handled. One way of securing this result is to design the castings with cored holes wherever metal may be eliminated without unduly affecting the strength of the tool. Where jigs are provided with feet, some designers favor the use of three feet, because with such an arrangement they are always sure of the jig taking a firm bearing on the machine table. As a matter of fact, this is an undesirable form of design, because there is nothing to show the presence of chips or other foreign matter under one of the feet of the jig or fixture, which would cause inaccuracy in the setting of the work. With a design in which four feet are provided, the presence of anything under one of the feet will immediately be shown by the fact that an improper bearing is provided and the jig will tend to rock in an unsteady manner until the trouble has been corrected.

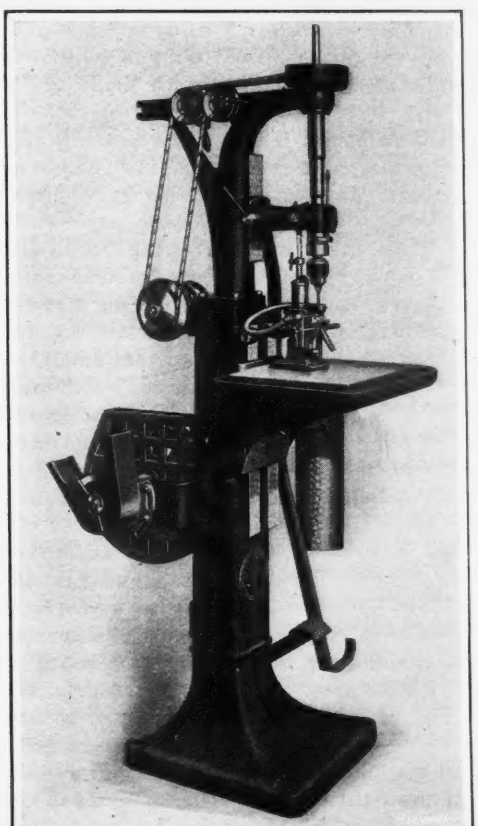

Fig. 3. Leland-Gifford Sensitive Drilling Machine with Special Jig for drilling Cross-holes in Pins

Materials Used in Making Jigs and Fixtures

Opinion differs as to the relative merits of cast iron and steel for use in making the bodies of jigs and fixtures. In deciding this point, attention should be given to the use to which the tool is to be put and the character of the work which it is to handle. It is difficult to make a general statement, but the best opinion seems to be that for small and medium sized work, such as parts of sewing machines, typewriters, adding machines, cash registers, phonographs, guns, etc., the steel jig offers decided advantages; but in the case of large work of the kind that has to be machined in factories engaged in the manufacture of machine tools, engines and automobiles, cast iron is undoubtedly the cheaper and more satisfactory material from which to make the castings.

Summary of Desirable Features to Include in Design of Jigs and Fixtures

In presenting the following summary of the features which should be provided in designing jigs and fixtures, the idea is to furnish data which the tool designer may run over in checking up his design. Experienced men will not find it necessary to take such precautions, but in the case of designers who have not had an opportunity to gain the necessary experience to make their judgment absolutely reliable, checking over a design to see that it meets the following requirements will often be the means of saving costly mistakes. These requirements may be briefly summarized as follows:

(A) Does the estimated production cost of drilling work in the new jigs and fixtures show sufficient saving over the cost with existing tool equipment to warrant ordering new tools? (B) Were locating points selected and the method of clamping decided upon before laying out the jig or fixture? (C) Have all clamping devices been made as quick-acting as possible? (D) Were locating points for use in machining component parts selected on corresponding surfaces on these parts? (E) Has the jig or fixture been made fool-proof, *i. e.*, is it arranged so that work cannot be inserted except in the correct way? (F) If the jig is used for holding rough castings, has adjustment been provided for the locating points to compensate for variations in the size of the castings? (G) Are all clamps located in the best position to resist pressure of cutting tool? (H) Have all clamps been made integral parts of the jig or fixture where possible? (I) Has the design of the clamping mechanism been simplified as far as possible? (J) Has provision to avoid springing the work been made by placing all clamps as nearly as possible opposite to bearing points on the work? (K) Has the jig or fixture been made as light as is consistent with rigidity and stiffness by coring out unnecessary metal? (L) Have all corners been made round? (M) Have handles been provided where these will make handling of the jig or

fixture more easily accomplished? (N) Has adequate support been provided by placing feet, etc., directly beneath all points where the pressure of cut will come? (O) Has ample clearance been provided in jigs or fixtures used for drilling rough castings? (P) Have all locating points been made visible to the operator while placing work in position in the jig or fixture? (Q) Have holes been provided for the removal of chips from the jig or fixture? (R) Have clamping lugs been located in such a way as to prevent springing the fixture in cases where the fixture must be secured to the drilling machine table? (S) Have instructions been given for the jig or fixture to be tested before it is sent to the shop to be used?

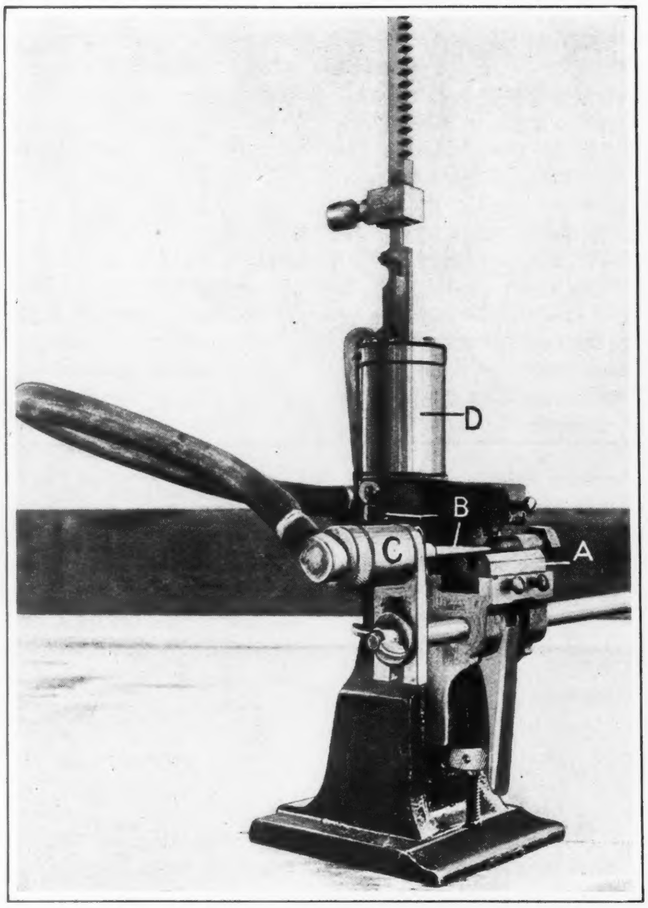

Fig. 4. Quick-acting Jig made by Caulkins & Carpenter for drilling Cross-holes in Pins

Types of Jigs and Fixtures

The variety of different jigs and fixtures which are in use at the present time is so great that the scope of an article of this kind does not include completè discussion. At the same time, the principles which have just been enunciated apply to all of these different types, and if carefully followed will be the means of greatly improving the efficiency of results secured with the auxiliary equipment designed for use on the drilling machines. Briefly stated, there are three different types of jigs and fixtures used on drilling machines, and mentioned in the order in which they are most generally employed, these are as follows: (1) Jigs or fixtures in which work is held to have one or more holes drilled in its top face. (2) Indexing jigs or fixtures used to provide for the performance of a sequence of operations; such fixtures are furnished with a loading station at which finished pieces may be removed and new parts substituted while pieces held in other sections of the fixture are being drilled. (3) Box jigs in which the work is secured; such jigs are furnished with feet on two or more surfaces, so that the jig may be turned over to provide for drilling one or more holes in two or more surfaces on the work.

Types of Drilling Machines

Drilling machines which find the most general application in American manufacturing plants may be roughly divided into three general classes, as follows:

1. Vertical drilling machines.
2. Radial drilling machines.
3. Multiple-spindle drilling machines.

Each of these general classes is capable of further subdivision, so that drilling machines are finally classified under the following headings:

1. Vertical or "upright" drilling machines.
2. Vertical sensitive drilling machines.
3. Vertical high-duty drilling machines.
4. Radial drilling machines.
5. Multiple-spindle drilling machines of straight-line type.
6. Multiple-spindle drilling machines of cluster type.
7. Automatic drilling machines.
8. Turret-type drilling machines.

In addition to the eight preceding types of machines a great deal of useful work is done by special machines built to meet the requirements of individual cases. Such machines are generally of the multiple-spindle type, but they are especially designed for specific classes of work.

Vertical or Upright Drilling Machines

This is the most commonly used type of "drill press" used in the machine shop. It is usually equipped with power feed, and a tapping attachment is often provided, which may be engaged to provide for handling work in which holes have to be tapped.

Vertical Sensitive Drilling Machines—The term "sensitive" is applied to those types of light drilling machines which are equipped with hand feed, so that the operator is able to judge the amount of feed pressure with which the drill is being driven into the work. These machines are usually adapted for drills from the smallest sizes up to from 3/8 to 7/8 inch in diameter. They are used on a great variety of work, and for handling small parts in quick-acting jigs or fixtures they are capable of giving very satisfactory results. One advantage of the hand feed is that an experienced operator may use his judgment in releasing the feed pressure, if he finds the drill has struck a hard spot in the work. This is the means of saving the breaking of drills. Machines of this type are now being built for operation at speeds which were unheard of a few years ago. For instance, some types of sensitive drilling machines are built for operation at speeds ranging from 10,000 to 15,000 revolutions per minute.

Vertical High-duty Drilling Machines—As their name implies, high-duty drilling machines are adapted for the performance of heavy work, and they are commonly employed for using a range of drill sizes running from the maximum capacity of sensitive drilling machines up to the largest sizes in which drills are made. In addition to the performance of drilling operations, high-duty drilling machines are used for a great variety of other classes of work, including such operations as hollow-milling, spot-facing, facing, counterboring, threading, tapping, etc. In general, machines of this character may be employed to advantage wherever it is desired to use a rotating tool on stationary work under conditions where heavy cuts are to be taken. To meet the requirements of such severe service, the high-duty drilling machine is equipped with power-driven feed, and the rates of feed are commonly much greater than that employed on sensitive drilling machines, while the speed at which the drill is operated is correspondingly reduced, owing to the greater diameter of the drill. There are various forms of mechanisms used on these machines, but in all cases provision is made for obtaining any of a range of speed and feed changes suitable for the work on which the machine is engaged.

Radial Drilling Machines—On the familiar type of radial drilling machine the spindle head is carried on an arm, which may be swung around the column of the machine, and the spindle head may also be moved back and forth along the arm. This combination of movements makes it possible to locate the spindle of a radial drilling machine at any desired point over work which comes within this range of movement. Radial drilling machines are commonly classified according to the length of arm, *i. e.*, a 6-foot radial drill has an arm 6 feet in length. Sizes in which these machines are generally built run from about 2½ to 6 feet. Obviously, the size of the work which can be handled with a machine of this type is governed by the length of arm and vertical adjustment of the arm on the

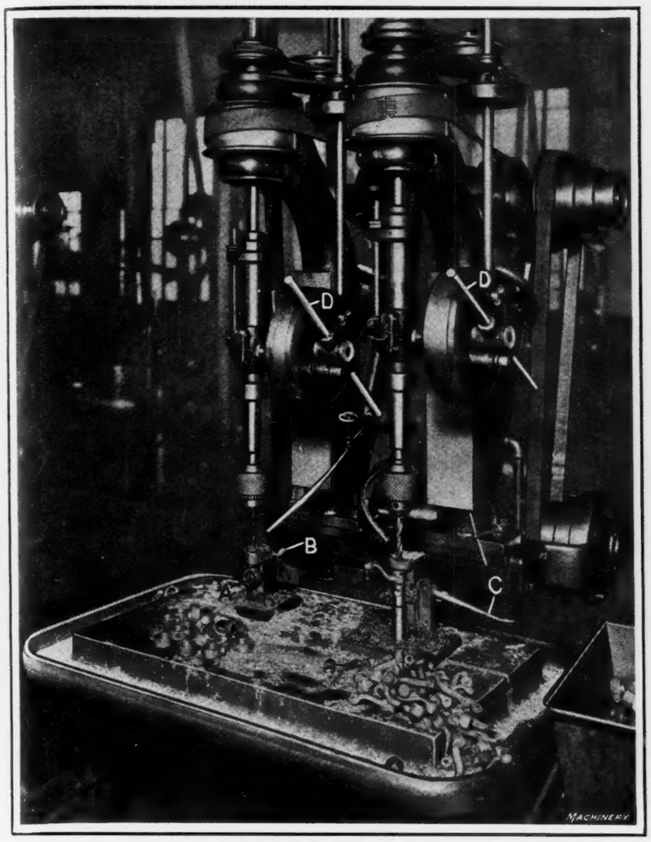

Fig. 5. Leland-Gifford Sensitive Drilling Machine equipped with Power Feed which enables One Operator to keep Two Spindles constantly in Operation

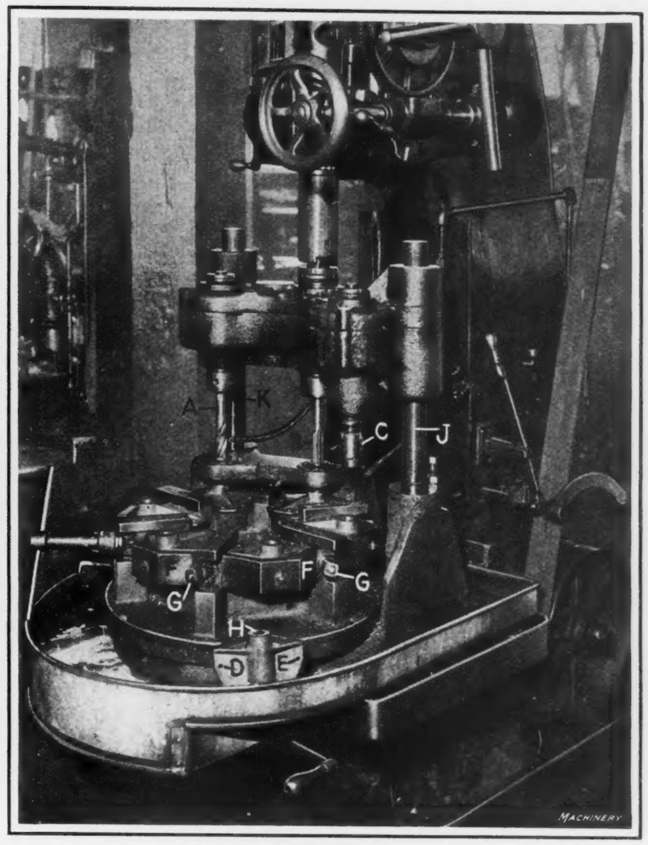

Fig. 6. Baker Bros. High-duty Drilling Machine equipped with Indexing Fixture and Special Three-spindle Head for drilling, reaming and facing

machine column. Radial drilling machines are generally employed for handling those classes of work where there are a number of holes to be drilled and where the work is either too heavy or too large to be conveniently set up on multiple-spindle drilling machines.

Multiple-spindle Drilling Machines of the Straight-line Type—The familiar vertical drilling machine is commonly built with from one to six spindles, and the terms "multiple spindle" and "gang" are used somewhat indiscriminately in referring to machines of this type. Probably the best opinion favors the use of the term "gang" in cases where separate drilling machine units with individual drive are bolted to a common bed casting, while the term "multiple spindle" is understood to designate machines of this type on which all of the spindles are carried in a machine frame of unit construction and are driven by a common driving shaft. In any case, the use made of both gang and multiple-spindle machines covers two general classes of work. In one of these the machine is employed for the performance of a sequence of operations on a piece of work which is passed along from spindle to spindle. On work of this type one or more operators are employed, according to the length of time required to perform the various drilling, counterboring and tapping operations. The other general class of work handled on straight-line multiple-spindle or gang drilling machines is where it is required to drill a number of holes in a piece, a case in point being where a line of holes are to be drilled in a pipe. For operations of this kind the machines are so equipped that all of the spindles feed down and return together.

Multiple-spindle Drilling Machines of the Cluster Type—To obtain efficient results in the performance of drilling operations, the keynote of success in securing a satisfactory rate of production is often found in a satisfactory solution of the problem of properly balancing the ratio of drilling time to setting-up time. If proper means are not provided to reduce setting-up time, this will often become so excessive that the production of the machine is far below the normal rate which ought to be secured. For work where there are a large number of holes to be drilled, profitable use may be made of multiple-spindle drilling machines. These are built with different numbers of spindles, arranged in a "cluster," and furnished with the necessary adjustment to enable the spindles to be set in the desired positions for drilling different groups of holes. The possibility of drilling a number of holes simultaneously, after setting up the work once, is obviously the means of greatly increasing the productivity of the machine.

Automatic Drilling Machines—For drilling holes in small parts, and particularly in those cases where the diameter and depth of the holes are not great, profitable use may often be made of automatic drilling machines. These are built in various types, which will be illustrated and described, but in each case the aim is to provide means of keeping the drilling spindle or spindles constantly employed while the operator is removing drilled pieces from the work-holding fixtures and loading fresh blanks into these fixtures, so that the parts may be drilled when they have been carried around under the drilling spindles. Surprisingly high rates of production can be obtained from machines of this type.

Turret Type of Drilling Machines—Drilling machines of the turret type fill the same general place among drilling machines that is taken by the turret lathe among machines of that type. In other words, turret drilling machines are used in those cases where there is a sequence of such operations as drilling, counterboring and tapping to be performed on a piece of work. Machines of this type are equipped with a turret carried on a horizontal axis about which the turret may be revolved to bring the sequence of tools into the operating position. In general, turret type drilling machines are used as an alternate method of handling those classes of work which are commonly handled on multiple-spindle drilling machines of the straight-line type, where work is passed along from spindle to spindle.

Having made a brief statement concerning the different types of drilling machines and classes of work for which each is adapted, we are ready to enter into a detailed discussion of installations of the different types of machines, showing examples of work for which each type is well adapted, and explaining the methods of setting up the work and giving rates of production that are obtained under favorable conditions. The same order will be followed in discussing the use of these machines as that which was followed in mentioning the different types.

Operation of Vertical or Upright Drilling Machine

Fig. 1 shows a group of three upright drilling machines built by the Rockford Drilling Machine Co., engaged in drilling

universal joint rings; and a fourth machine to the left is employed for reaming the holes. It will be seen that the three drilling machines are equipped with indexing jigs to provide for bringing the work into the required positions for successively drilling each of the four holes. A detailed view of the indexing jig is shown in Fig. 2. Referring to this illustration, it will be seen that work *A* is clamped in place under bushing *B* and that provision for locating the work in the four drilling positions is made by means of index plate *C* and spring plunger *D*. The work to be drilled is a drop-forging containing from 0.15 to 0.25 per cent carbon, from 0.30 to 0.60 per cent manganese, sulphur below 0.045 per cent, and phosphorus below 0.05 per cent. The holes to be drilled are 1 inch in diameter by 9/16 inch in depth. The production is approximately 600 completed rings on the three right-hand drilling machines in a ten-hour working day, *i. e.*, 2400 holes are drilled per day in these forgings.

High-speed Ball Bearing Sensitive Drilling Machines

To take advantage of the benefits which are secured through the performance of drilling operations at high speed, the Leland-Gifford Co. builds a line of ball bearing sensitive drilling machines which are adapted for operation at speeds ranging from 10,000 to 15,000 R.P.M. These machines are built in a bench type or with a pedestal base so that they may be set up on the floor. Fig. 3 shows one of the pedestal type machines equipped with a special drilling jig built by Caulkins & Carpenter, and a better idea of the way in which this outfit operates will be gathered from Fig. 4. This jig is especially suited for use in drilling cross-holes in pins and similar shaped parts, and to meet the requirements of such work it is furnished with a V-block *A* to hold the work and an end-stop *B* to locate the work in the desired position in the jig. End-stop *B* is connected to a piston in air cylinder *C*, and this cylinder is connected by a rubber hose with cylinder *D*. A rack, which meshes with the feed pinion on the machine, is carried at the upper end of a rod connected with the piston in cylinder *D*, and it will be apparent that during the time that the drill is being fed into the work, the rack carried at the back of the feed pinion is raised, thus raising the piston in cylinder *D*.

After the drilling operation has been completed and the drill spindle starts to rise, the reverse movement of the feed pinion results in driving down the piston in cylinder *D*, and this results in driving air through the flexible tube into cylinder *C*. The result is that end-stop *B* is driven forward and ejects the drilled piece from the V-block. During this time the operator has picked up another piece of work which he can immediately place in position ready to be drilled, so that the operation of the machine may be practically continuous. When the work has been placed in the V-block, and the drill starts to feed down, raising of the piston in cylinder *D* results in actuating a link mechanism at the back of the jig, which is responsible for clamping the work in place. It will also be apparent from the illustration that the V-block which supports the work is carried on a knee which may be adjusted vertically to provide for holding pieces of various diameters; the rod which carries end-stop *B* and cylinder *C* may also be adjusted in its bearing in the knee to provide for drilling pins of different lengths, and it is obviously an easy matter to substitute drill bushings of the correct size for handling different operations. Drilling holes through pins made of screw stock 3/16 inch in diameter with a No. 51 drill, the machine was operated at 6700 R.P.M. and produced 2200 pieces an hour. Such a high rate of production would not be possible were it not for the provision made in designing this jig for rapid handling.

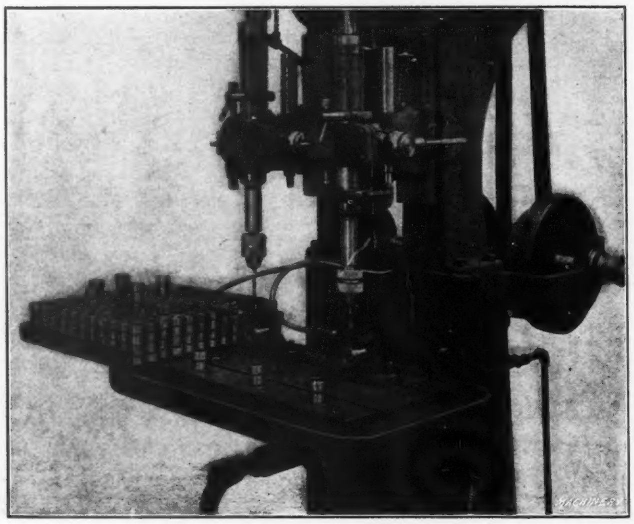

Fig. 7. No. 2½ "Avey" Ball Bearing Sensitive Drilling Machine set up for Use in drilling Steel Bushings. On this Operation the Production is 10,000 Bushings in a Ten-hour Day

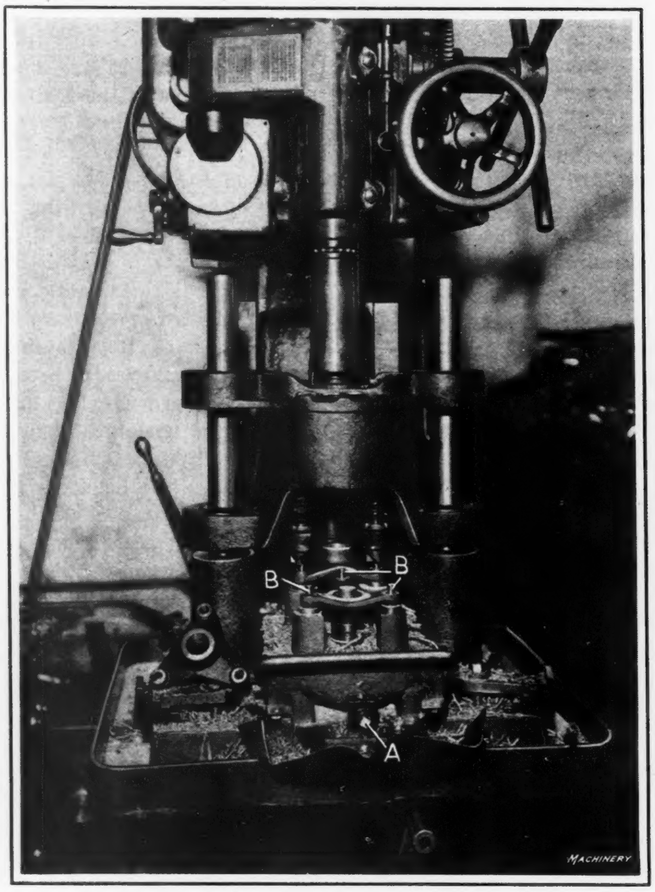

Fig. 8. Baker Bros. High-duty Drilling Machine equipped with a Two-station Work-holding Fixture and Special Three-spindle Head for spot-facing

Fig. 5 shows a high-speed, ball-bearing sensitive drilling machine built by the Leland-Gifford Co. The spindles are mounted in ball bearings, so that it is adapted for running at speeds up to 3500 revolutions per minute. It is known as a semi-automatic machine, and in this respect deviates from what is generally understood to constitute a sensitive drilling machine, because the spindles are equipped with power feed. In operating the machine one man attends to both spindles; he sets a piece of work up in one fixture and engages the power feed, then reaches over to the second fixture, removes the drilled piece of work, sets up a fresh piece in the fixture, and engages the power feed. By this time the drilling operation on the piece under the first spindle has been completed, at which time the feed is automatically tripped and the spindle returned to the starting point, so that the operator merely has to remove the drilled piece and substitute a fresh blank. In this way both spindles of the drilling machine and the man employed to operate them are kept busy almost all of the time, so that an unusually high rate of efficiency is secured. The lever which engages the power feed clutch may also be used to feed the drill by hand; and by simply pushing up this lever, the power feed may be instantly disengaged in any position, without waiting for the full downward movement to be completed. This last-named feature is often of great convenience.

Particular attention is called to the design of the jigs used on this machine. In the case of the 7/8-inch set-collar shown under the left-hand spindle, the operation consists of drilling a 1/4-inch tap-hole which is 3/8 inch deep in a malleable iron part. The work is slipped over pilot *A* and secured by a bell-mouthed bushing operated by lever *B*. In the case of the malleable iron cranks which are being drilled under the right-hand spindle, a bell-mouthed bushing is also employed to secure the work, this bushing being operated by lever *C*. In this case a stronger spring is required to hold the work, and so it was necessary to make the lever longer. The hole being drilled in these cranks is 3/8 inch in diameter by 3/4 inch deep. It will be apparent that in both cases work may be set up and removed with a minimum expenditure of time, which is important, because the operations are soon finished. In drilling the set-collars the operation is performed at 1100 R.P.M. with a feed of 0.005 inch per revolution and the production is 4800 pieces per eight-hour day. In drilling the small cranks, the drill runs at the same speed and feed and 2400 pieces are produced in eight hours. The power feed used in this machine is so designed that when the operator grasps either of the feed levers *D* and pulls it forward, feed is engaged and the drill is advanced into the work by power until an automatic trip throws out the feed clutch, at which time the spindle is automatically returned to the starting position. Graduated circles which are furnished on each of these feed clutches provide for setting the feed to be tripped after a hole has been drilled to a predetermined depth.

Fig. 7 shows a No. 2½ high-duty, ball-bearing sensitive drilling machine built by the Cincinnati Pulley Machinery Co. This machine is illustrated in use drilling steel bushings where it is required to drill a 17/64-inch hole through a wall 9/32 inch in thickness. These pieces are turned out by an unskilled operator at the rate of 1186 pieces per hour, or approximately 10,000 pieces in a ten-hour day. The daily figure allows time for changing drills and for further unavoidable losses. Machines of this type are built with either plain hand feed or with power feed, and means are provided for automatically reversing the travel of the spindle in one or both directions. The machine equipped with automatic feed mechanism is quite flexible, it being possible to operate it as a fully automatic or semi-automatic machine, or the automatic mechanism may be entirely disconnected and the machine fed by hand. In shops which have pieces that are manufactured in large quantities, and where the nature of the work is such that it may be rapidly set up and removed from fixtures, the fully automatic mechanism is usually employed. On the other hand, where the work is comparatively difficult to handle, more time will be required between successive strokes of the drill, and for such work the automatic trip for the down-feed of the drill is thrown out. In this case the return of the spindle is automatic, but the power feed clutch must be engaged by hand. For still other classes of work all of the automatic movements are disconnected. The trips for the automatic movements may be set so that the time between strokes is just enough to allow the operator to remove the drilled piece and substitute a fresh casting.

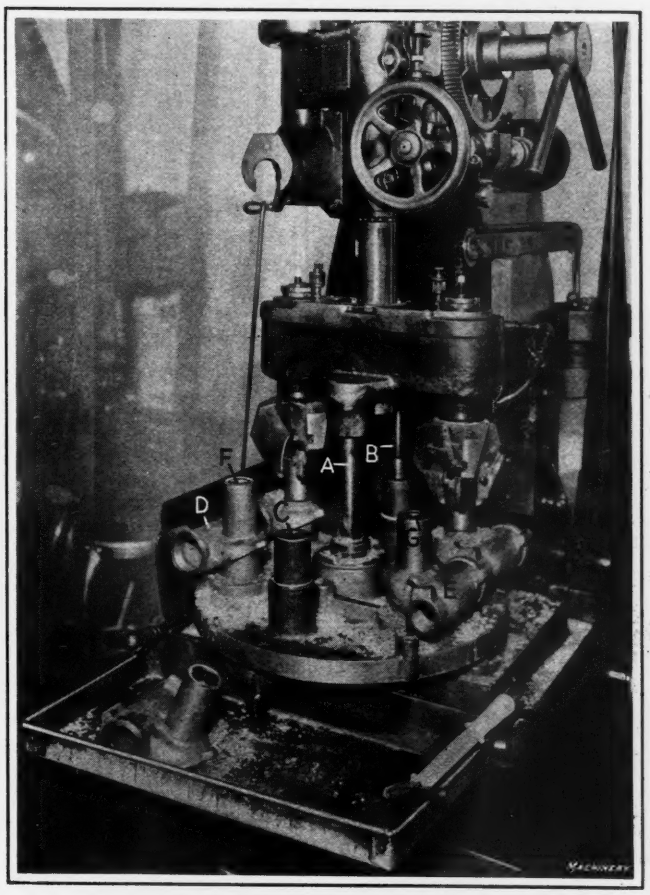

Fig. 9. Baker Bros. High-duty Drilling Machine equipped with Indexing Fixture and Two-spindle Head for hollow-milling Steering-gear Housings

Vertical High-duty Drilling Machines

For drilling, reaming and facing the 0.998-inch hole in rear spring center brackets used in the construction of automobiles of its manufacture, the Willys-Overland Co. employs high-duty drilling machines built by Baker Bros., one of these machines being shown in operation in Fig. 6. On this job the nature of the work is such that a considerable amount of time must necessarily be employed in setting the work up in the fixture, but as the depth of the hole to be drilled, reamed and faced is also considerable, this need not constitute an unsurmountable barrier against the attainment of efficient production. The problem has been adequately solved through adoption of the use of an indexing work-holding fixture. The pieces have to be drilled, reamed and faced, and these operations are performed by tools shown at *A*, *B* and *C*, respectively. The drilling operation naturally consumes the greatest amount of time, and while the drill is in operation the workman has ample time to remove one drilled piece from the loading station at the front of the fixture and substitute a fresh blank; then, when the machine spindle lifts the multiple head which drives the three tools, the operator pushes the fixture around until the index pin locates it at the next station. For each traverse of the drilling machine spindle it will be apparent that one finished piece is produced, as the drilling, reaming and spot-facing operations are performed simultaneously.

The work is malleable iron, and referring to the piece shown leaning against the fixture at the front, attention is called to the fact that two locating pins enter holes *D* and *E*, which were drilled in a previous operation. Swinging clamp *F* is then brought up against the front of the work and secured by nut *G* that is tightened with a wrench. The hole *H* to be drilled is 0.998 inch in diameter by 3 1/16 inches deep, and the rate of production is 600 pieces per eight-hour day. The operation is performed at a speed of 300 R.P.M. with a feed of 0.024 inch per revolution. The machine is equipped with a three-spindle auxiliary head built in the Willys-Overland factory, and attention is called to the pilots *J* and *K*, which extend up from the work-holding fixture into bushings in the drill head, thus assuring permanent alignment.

In connection with the general discussion of high-duty drilling machines, mention was made of the fact that machines of this type are well adapted for the performance of many other operations besides drilling. In Fig. 8, one of the Baker high-duty drilling machines is shown set up to provide for simultaneously spot-facing three pads on a universal joint spider. The machine used for this purpose is equipped with a three-spindle multiple head, and this head is piloted from the fixture, as in the preceding case. The pads on these spiders have to be spot-faced on both sides, and to provide for turning over the work or for removing a finished piece from the fixture and substituting a fresh malleable iron casting, so that idle time of the machine may be reduced as far as possible, use is made of a sliding fixture of the type shown. This fixture is furnished with two stops, one of which is shown at *A*, which limit the travel of the fixture in either direction to provide for locating the work supported at one or the other of the two stations on the fixture under the spot-facing tools. The

holes in these spiders have already been drilled, and these are employed as locating points; in addition, the pins *B* which locate the work from these holes extend up sufficiently through the work so that the spot-facing tools may be piloted over them to assure rigidity. Owing to the clever way in which the design of this fixture has been worked out and applied, these malleable iron spiders may have three pads spot-faced on both sides with a production of 288 parts per eight-hour day from each machine. The machine is run at 200 R.P.M. with hand feed.

Another example which tends to show the range of work that may be efficiently handled on high-duty drilling machines is illustrated in Fig. 9, which shows the operation of hollow-milling steering-gear housings for the Willys-Overland car. Here, again, use is made of an indexing work-holding fixture, and the machine is equipped with a special two-spindle auxiliary head. To provide the degree of rigidity that is required under severe service of this kind, however, the system of piloting is somewhat different from that shown on preceding machines of this type. In this case two pilots are employed; the central pilot *A* is carried by the fixture and runs in a bushing in the drill head, while pilot *B* is carried by the head and runs in sockets carried by the fixture. This fixture is indexed through 180 degrees, and in this position pilot *B* will run in socket *C*. In performing this hollow-milling operation, the two pieces of work *D* and *E* are dropped over pilots on the fixture and the ends of these pieces simply bear against lugs on the fixture which prevent them from turning. Where this method of securing work can be employed, it is extremely satisfactory, because the length of time required to set up the work in place for machining is reduced very close to a minimum. The holes have been machined by a previous operation and are employed as the locating points. After setting up the work the fixture is indexed through 180 degrees, as previously mentioned, and this brings the blanks into the position shown in the illustration where two pieces may be milled simultaneously. The hollow-milling cutters used on this machine are provided with pilots which enter bushings *F* and *G* in the studs on which the work is carried, so that further provision is made to guard against vibration. The length of time consumed by this hollow-milling operation is ample to allow the finished pieces to be removed from the fixture and new blanks to be set up. The material is malleable iron; and the surface finished during this operation is 3¼ inches in length by 2¼ inches in diameter; the rate of production is 160 pieces per eight-hour working day. This operation is performed at 70 R.P.M. with a feed of 0.010 inch per revolution.

By employing a carefully worked out design for tools and work-holding fixtures, there are many classes of work on which a considerable sequence of operations may be performed through the use of high-duty drilling machines. An excellent example of this kind is shown in Fig. 10, which illustrates one of the Baker high-duty drilling machines equipped with tools and an indexing fixture to provide for boring and reaming holes of three diameters in the Willys-Overland steering-gear housing, facing the surface at the top of this housing, facing off a seat for the ball bearing, and tapping one of the bored holes. As in the preceding case, a double system of pilots is employed, one of which is secured to the work-holding fixture and enters a bushing in the three-spindle auxiliary head provided on the machine, while the other pilot is carried by this special auxiliary head and runs in a sequence of bushings provided for that purpose in the work-holding fixture. Rough-boring of the holes of different diameters is performed by bits carried in bar *A*. Then, when the work is indexed to the next position, the combination reaming and facing tool *B* reams the three bored holes and faces both the top of the steering-gear housing and the ball bearing seat. After this has been accomplished, the work is indexed once more and the tap *C* cuts the thread in the large hole. To provide for this last operation, the tapping spindle is furnished with a hand-feed lever *D*, and after the tap has penetrated to the desired depth, it is reversed and backed out of the hole by gearing operated by lever *E*.

In this connection attention is called to the fact that all the auxiliary heads employed on these heavy-duty Baker Bros.

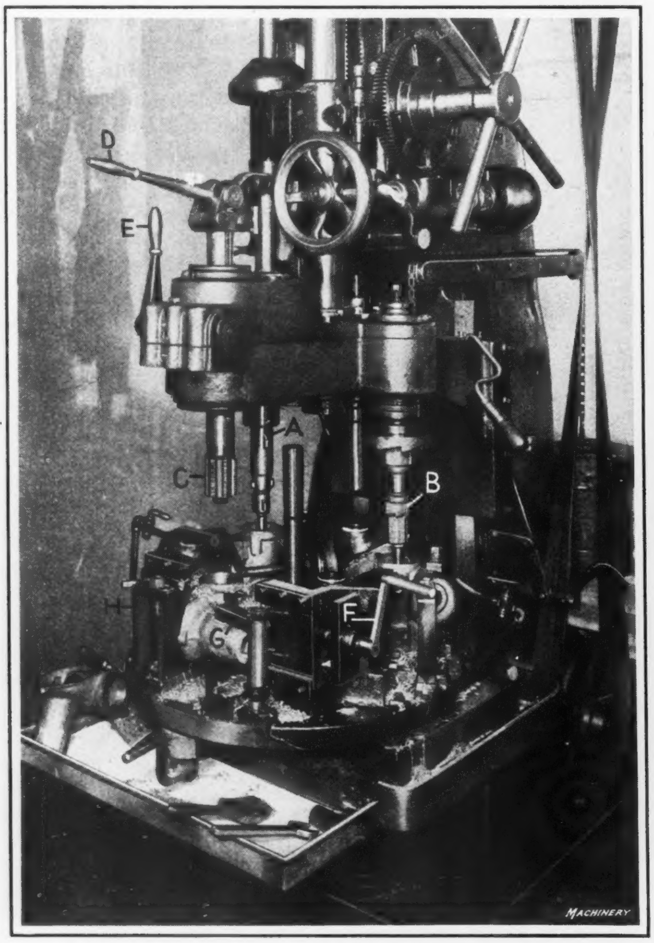

Fig. 10. Baker Bros. High-duty Drilling Machine with Indexing Fixture and Three-spindle Head for boring and reaming Three Holes, facing Two Surfaces and tapping One Hole

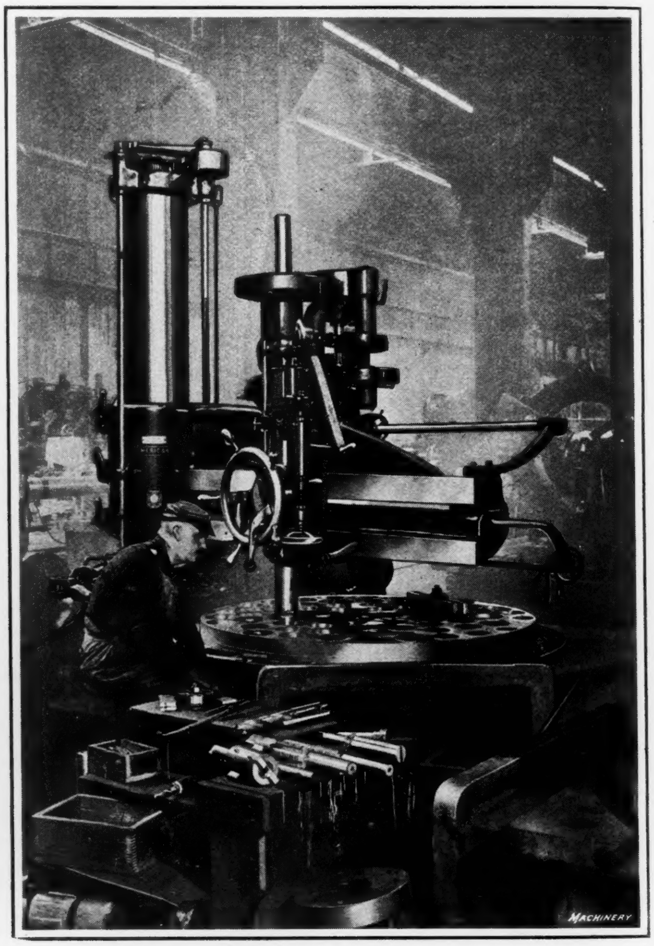

Fig. 11. Radial Drilling Machine built by American Tool Works Co. engaged in Operation of machining Air-head of Mesta Blowing Engine

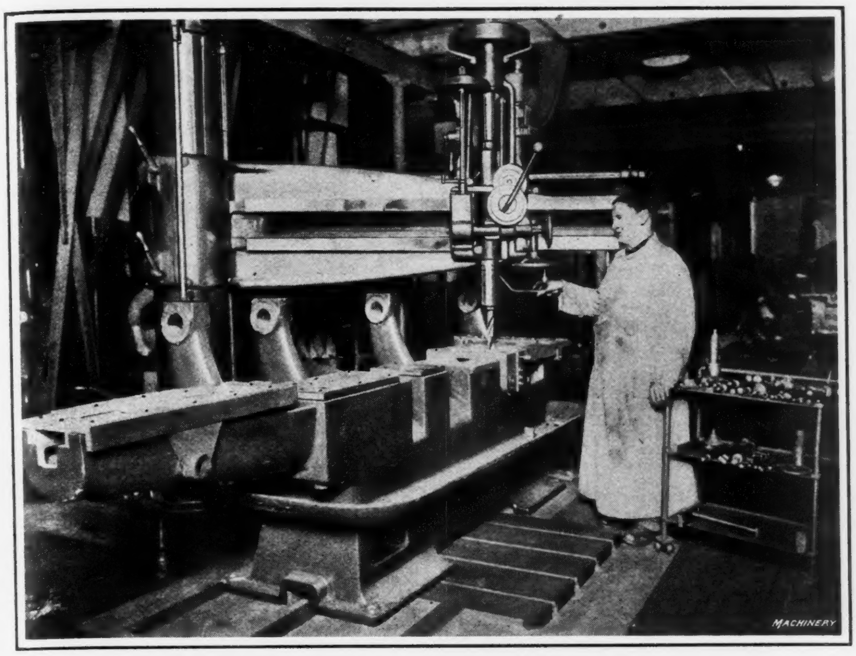

Fig. 12. Radial Drilling Machine built by Cincinnati Bickford Tool Co. engaged in drilling Bed of Cleveland Automatic

drilling machines are counterweighted, the arrangement being clearly shown at the right-hand side of the machine shown in Fig. 10. The fixture used to support the work for performing the preceding operations is quite interesting. The work is placed over a pilot that enters a hole bored by a preceding operation, and is then clamped at either end by jaws actuated by a screw threaded right- and left-hand at opposite ends, which is turned by crank *F*. The work is further secured in place by clamp *G*, and in this connection attention is called to the second clamp *H*, which is not in use. The reason for this is interesting, as it shows an economy effected in the design of work-holding fixtures. Cars built for American use are generally equipped with the steering-wheel at the left, while those exported to Europe have the steering-wheel at the right. This makes it necessary to machine steering-gear housings for both types of design, but to avoid the necessity of an additional investment in jig and fixture equipment, or the loss of time and incidental expense which would be involved in changing from one type of work-holding fixture to another, the fixture shown in Fig. 10 is made "universal," in that it will hold either type of steering-gear housings. The only change is that for holding a housing of the opposite hand, the piece will rest in the fixture in the opposite direction, and in that case clamp *H* will be employed and clamp *G* will remain idle. The holes bored and reamed during this series of operations are 2 3/8 by 13/16, 2 1/16 by 11/16, and 1 1/2 by 1 3/4 inch in diameter and depth, respectively; the first of these three holes is the one to be tapped. These pieces are made of malleable iron and the rate of production is 120 pieces per eight-hour day.

Radial Drilling Machines

Where there are a number of holes to be drilled over the area of a piece of work that is too large or too heavy to enable all of the holes to be conveniently reached by a multiple-spindle drilling machine, use is generally made of a radial drilling machine on which the combined movement secured by swinging the radial arm and adjusting the position of the drill spindle head on this arm will enable all of the holes to be reached with a single setting of the work. Radial drilling machines are also employed in some cases where the size of the holes to be drilled and the material is such that the service would be too severe for many classes of multiple-spindle machines. Fig. 11 shows a typical example of radial drilling machine work, which consists of drilling holes in the air-head of a blowing engine. The view shown is in the shops of the Mesta Machine Co., and the radial drilling machine is a product of the American Tool Works Co. In the Mesta Machine Co.'s shops radial drilling machines are also used to a considerable extent for the performance of machining operations on castings of such size and weight that they sometimes exceed the maximum capacity of the 75-ton electric cranes in the shop, and in any case would be far too heavy to enable them to be set up on any drilling machine. For this class of work the radial drills are furnished with eyes so that they can be picked up by the crane hook and carried to the work instead of following the general practice of taking work to the machine. For handling these exceptionally large pieces which are constantly going through the Mesta shops, the use of portable machines is practically a matter of necessity; at the same time, their application has been found beneficial in that it is possible to have a number of machines working simultaneously on one of these large castings, so that the time required to complete the various machining operations is substantially reduced.

Fig. 12 shows a radial drilling machine built by the Cincinnati Bickford Tool Co. This machine is shown engaged on a typical radial drilling operation, namely, drilling all of the holes in a machine bed casting. This machine is used in the plant of the Cleveland Automatic Machine Co., where it is engaged in drilling fifty-two holes in the bed of a Cleveland automatic. The operations comprise drilling, reaming, counterboring and tapping holes varying from 2¼ down to ¼ inch in diameter; the largest counterbore is 4 inches in diameter. The spindle of the machine is equipped with a quick-change chuck, and, located conveniently for the operator, there will be seen a portable stand on which are carried the different drills, counterbores, reamers, etc., which are required in carrying out the work.

Multiple Drilling Machines of Straight-line Type

In connection with the introductory statement concerning the classes of work handled on multiple-spindle drilling

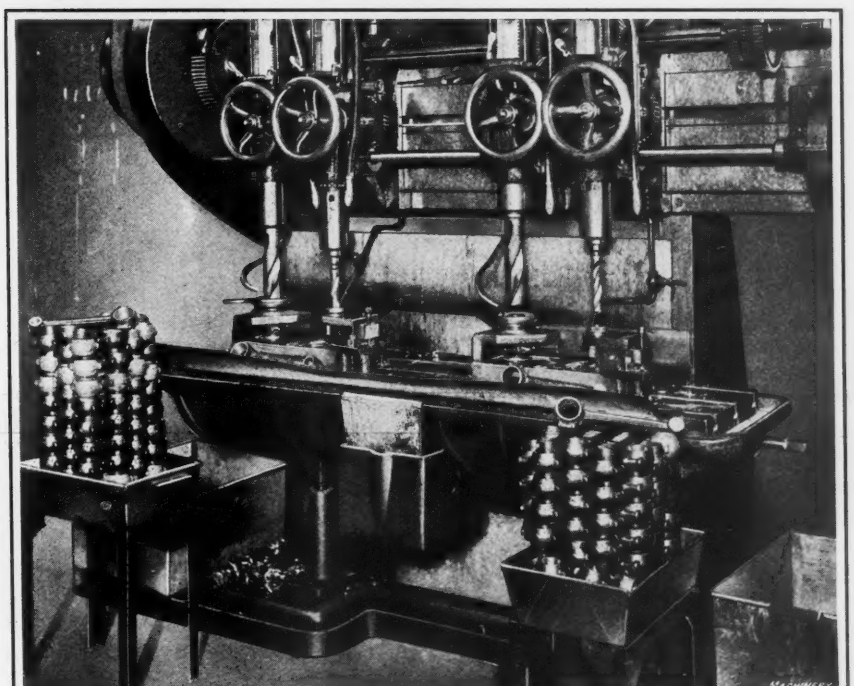

Fig. 13. Four-spindle Drilling Machine built by Foote-Burt Co. engaged in simultaneously drilling Both Holes in Two Connecting-rods

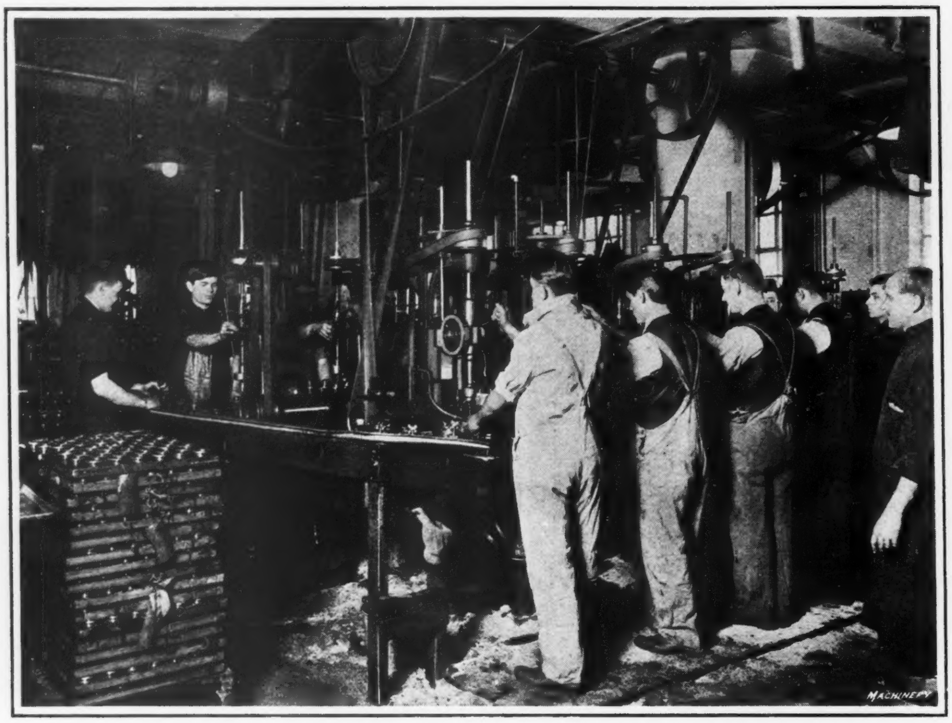

Fig. 14. Battery of Two Four-spindle Washburn Drilling Machines operated by "Team" of Ten Men for drilling and tapping Two Holes in Fuse Parts

machines of the straight-line type, mention was made of the fact that such machines are commonly employed for either simultaneously drilling a number of holes located in a straight line in a piece of work, or else that the machines are arranged to perform a sequence of operations on parts which are set up successively under the different spindles of the machine. In the latter case the operator moves progressively from spindle to spindle, removing drilled pieces and substituting blanks in their place ready to be drilled. Fig. 13 shows a special multiple-spindle machine of the straight-line type built for the Willys-Overland Co. by the Foote-Burt Co., which is engaged in the performance of drilling operations on connecting-rods. Here the work is of such character that two spindles are required for drilling each piece, but the length of these operations is sufficient so that a four-spindle machine may be employed to allow the operator to busy himself setting up work under one pair of spindles, while the other pair is engaged on the drilling operation on another part. In this way the operator is kept constantly employed. The work-holding fixtures used on this machine employ two principles which are often used in jig and fixture design for locating and securing the work in place. The small end of the connecting-rod is pushed into a V-block, which locates it under the drill, and after this has been done, a bell-mouthed bushing, through which the other drill operates, is screwed down onto the large end of the connecting-rod, thus locating this end in place to be drilled and also clamping the work in the fixture. With an arrangement of this kind the time involved in setting up the work is reduced to a point where lost time becomes unimportant. The material to be drilled is drop-forgings, the large hole being 2.188 by 1.688 inch deep; and the small hole is 1.123 by 1 5/16 incn deep. The operation is performed at a speed of 325 R.P.M. and a feed of 0.005 inch per revolution; the production is 720 crankshafts per eight-hour day from each machine.

For use in drilling and tapping nose adapters for shrapnel cases, excellent results have been obtained with an equipment consisting of two four-spindle drilling machines built by the Washburn Shops. These machines are of the power feed type and are placed back to back, as shown in Fig. 14, with metal covered shelves extending across the ends of the machines to provide for sliding jigs from one machine to the other. The work consists of drilling two holes, each of which must subsequently be tapped, the sizes being 3/8- and 3/16-inch tap holes. The interesting feature of this installation is the careful way in which plans were made to increase production as far as possible. About three dozen jigs were supplied and the "team" which operates this pair of machines consists of ten operatives, one at each of the spindles and one stationed at each end shelf, whose duty it is to remove finished pieces from the jigs and substitute fresh blanks. A piece is placed in a jig by one of the men stationed in the loading position, and this piece is passed along from spindle to spindle, so that the two holes are drilled and tapped by the four spindles of one machine unit. This piece is then removed from the jig and a fresh blank substituted, after which the jig is pushed across the shelf to the four men operating the machine at the opposite side of the group. In this way each jig goes round and round in a continuous circuit, and there is practically no loss of time. The order in which the operations are performed is as follows: drill 3/8-inch hole, drill 3/16-inch hole; tap 3/8-inch hole and tap 3/16-inch hole. These men work ten hours a day on a piece-work basis, and the normal rate of production is about 5500 pieces per working day for each gang. At times the production was increased to a considerable extent, but this is regarded more in the light of a "spurt" than normal operating conditions.

In the plant of the Hupp Motor Car Co. heavy-duty drilling machines, built by the Colburn Machine Tool Co., are used for drilling and reaming connecting-rods. A gang of four machines are used, which are equipped with a special combination table or track on which the jigs are slid along from one spindle to another, the arrangement being clearly shown in Fig. 15. Looking at the spindles from right to left, the first spindle at the right drills out the hole at the large end of the connecting-rod and the second spindle reams this hole; the third is a reserve spindle, the use of which will be explained later, and the fourth spindle drills the hole in the small end of the connecting-rod. One operator attends to the

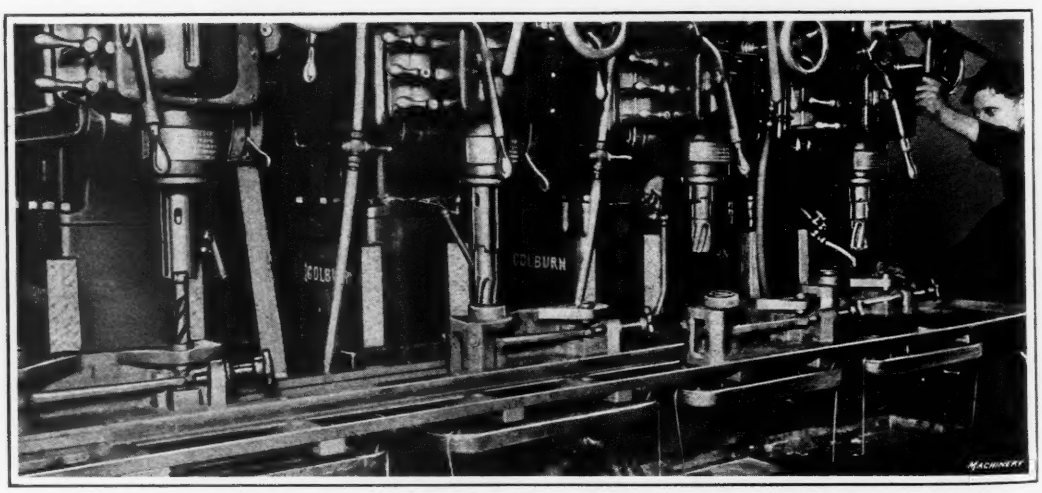

Fig. 15. Gang of Four Colburn High-duty Drilling Machines equipped with Sliding Jigs for drilling Hupp Connecting-rods. One Spindle is held in reserve to substitute as required

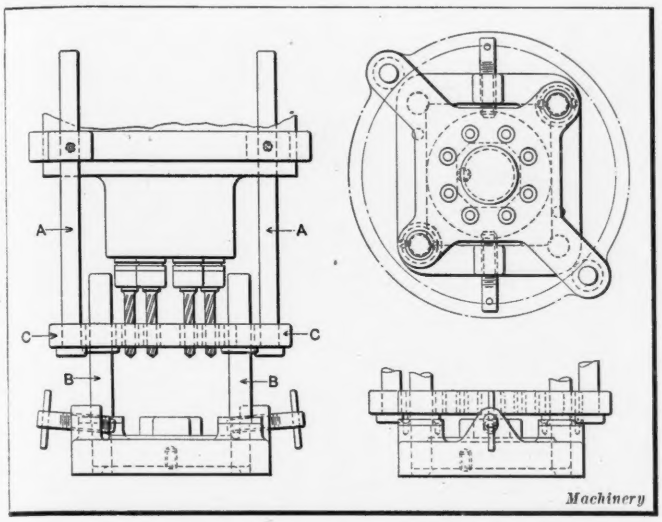

Fig. 16. Multiple-spindle Drill Head provided with Jig-plate that is lifted with Head when Spindle of Drilling Machine rises in order to facilitate Removal of Work from Fixture

whole battery of machines, and after he has started a drill working on one hole, he goes along to the next jig and gets it ready for operation. The jigs are never lifted, it being merely necessary for the operator to remove the drilled connecting-rod and insert a new forging after each operation. By having the drilling machines independently belted, it is possible to obtain any speed for any particular requirement, and should a breakdown occur on any spindle the other three spindles are not affected, as would be the case with a multiple-spindle machine of the straight-line type. In case of emergency, the reserve spindle can be quickly changed over to either tool that requires this spindle, so that production is not held up. The way in which the connecting-rods are held in the jigs is fairly apparent from the illustration. Both ends of the rod rest on finished pads in the jig, and by tightening the clamping screw the large end of the rod is forced between the ends of two converging studs that form the equivalent of a V-block. It will be seen that the clamping screw is inclined slightly downward so that it holds the work down on the supporting surfaces of the jig. The drop-forgings to be drilled contain from 0.035 to 0.045 per cent carbon. The hole to be drilled in the large end of the rod is 2 1/16 inches in diameter by 1 3/8 inch deep; and the hole in the small end of the rod is 0.864 inch in diameter by 7/8 inch deep. The rate of production secured on this job is 400 connecting-rods in a nine-hour working day.

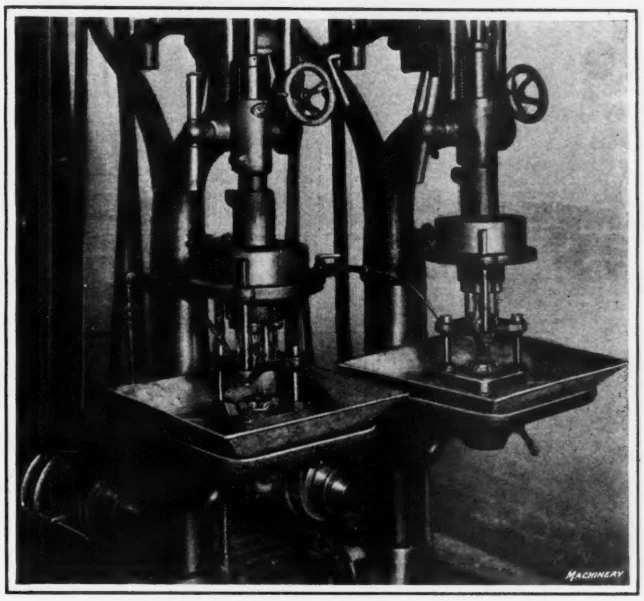

Fig. 17. Rockford Vertical Drilling Machines with Multiple Heads

Fig. 17 shows an interesting installation of vertical drilling machines built by the Rockford Drilling Machine Co., and equipped with multiple-spindle drill heads. The feature of this equipment is the provision of a jig-plate carried by the drill head, the idea being more clearly shown in Fig. 16, which gives a detailed view of the jig construction. It will be seen that this jig-plate comes down to the points of the drills, so that adequate support is provided during the intervals at which the drills are being started into the work; then the jig-plate remains on the work while the drills are fed in to the desired depth. While the drilling machine spindle is raised, the head carries the jig-plate up with it, so that there is no obstruction to hinder the operator in removing work from the fixture. The way in which this result is secured is as follows: When the drilling machine spindle is raised, heads at the lower ends of rods *A*, carried by the multiple head, lift the jig-plate. These arms are so adjusted that the jig-plate is held with its lower surface just above the drill points, as shown in Fig. 17. When the drills are fed down to the work, the jig-plate drops until further movement is retarded by flanges on rods *B* carried by the work-holding fixture. In this position the jig continues to support the drills, but the drills may be fed through to the desired depth. It will, of course, be apparent that jig-plate *C* is furnished with the usual arrangement of hardened steel bushings; and the work is held in the fixture by an arrangement of clamps which is quite apparent in the illustration. It will be seen that the drill heads shown on the machines in Fig. 17 are of four- and eight-spindle types, respectively, and the work to be drilled is two types of universal joint rings. The holes drilled by the four-spindle head are 5/16 inch in diameter by 3/8 inch deep, and the holes drilled on the eight-spindle head are 5/16 inch in diameter by 1/2 inch deep. The material is drop-forgings containing 0.025 to 0.035 per cent of carbon. The rate of production is from 1400 to 1500 rings in a ten-hour working day.

Compressed Air for Ejecting Work from Fixtures

Mention has already been made of the increased importance of designing fixtures to provide for the rapid handling of work on account of the reduction in drilling time which has been made possible through the design of high-speed machines. Fig. 18 shows the fixture used on a machine equipped with a two-spindle head which is used for drilling holes 0.107 inch in diameter in disks shown at *A*. A feature of this equipment is the provision for rapid handling of the work. A supply of disks is kept in feed-trough *B*, and as soon as one piece has been engaged by the drills, the operator lays his thumb on a second piece and starts to advance it to the drilling position. Location of the work is very simple, as it is merely necessary to slide the work into the notch *C*, which locates it under the drill spindles. When the drilling operation has been completed, the operator removes his thumb from the piece of work and reaches for another piece. As the spindle on the machine rises, a blast of compressed air through tube *D* blows the drilled work off the fixture and it drops through opening *E* into a receiver. At the back of the

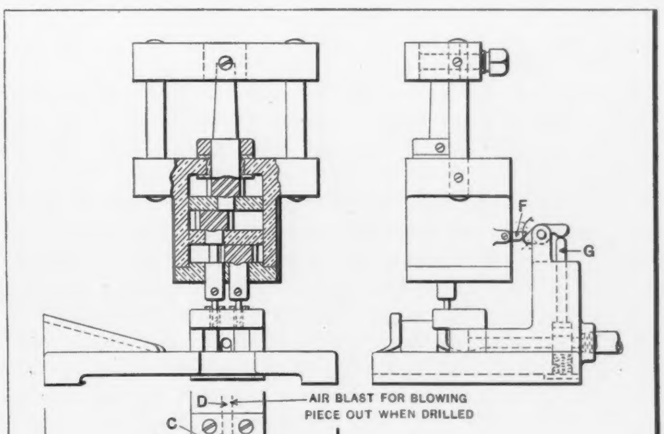

Fig. 18. Work-holding Fixture provided with automatically operated Air Ejector to discharge Work through Chute into Receiver placed under Drilling Machine

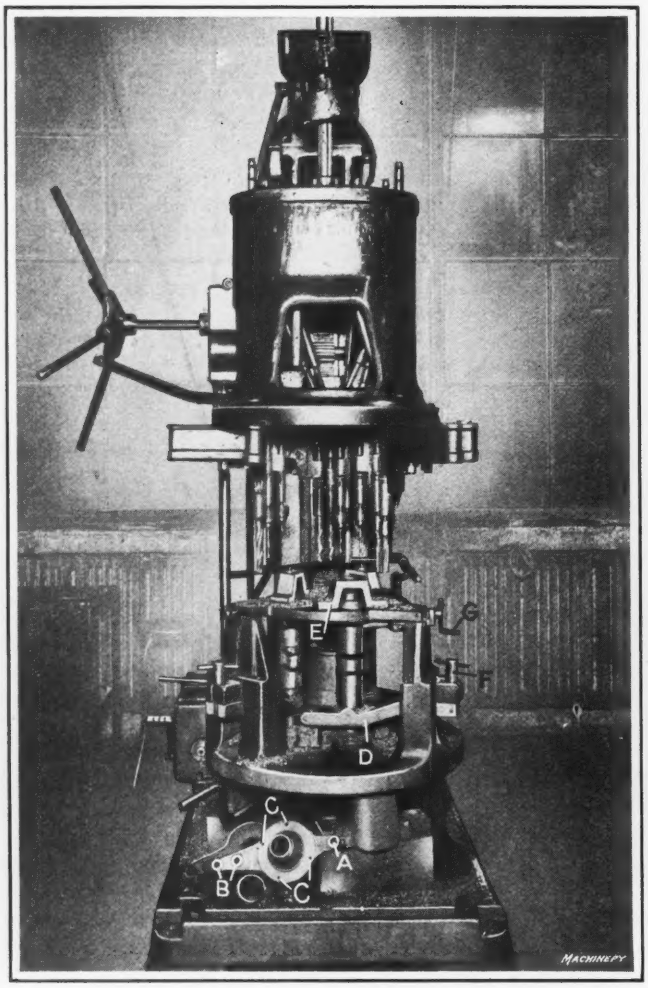

Fig. 19. Ten-spindle Drilling Machine built by National Automatic Tool Co. engaged in drilling and reaming Rear Axle Spiders

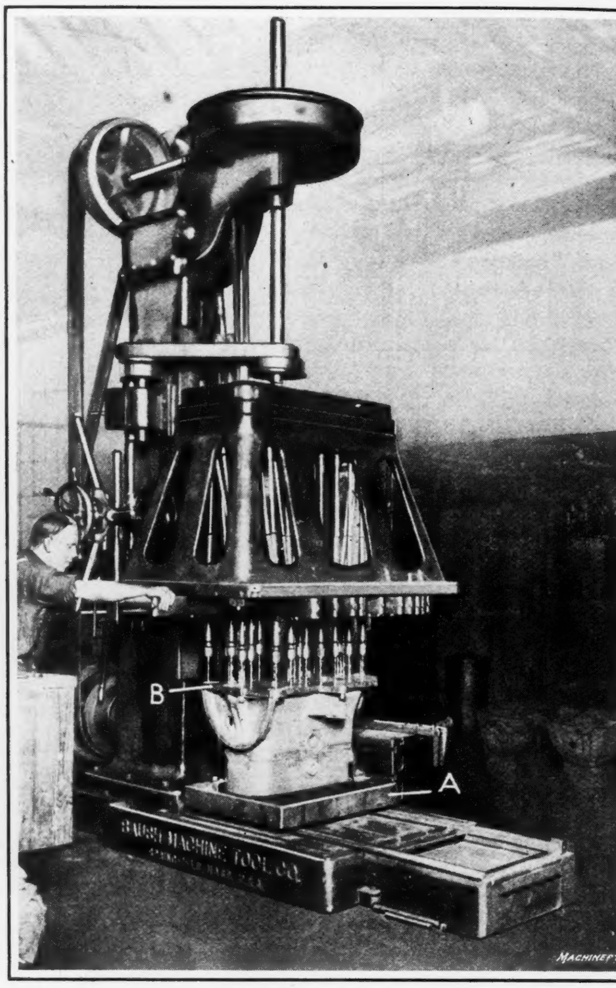

Fig. 20. Baush Multiple-spindle Drilling Machine equipped with Sliding Fixture to facilitate loading Casting in Fixture and removing Drilled Work

drill head it will be seen that there is a stud *F* that engages a trip which actuates air-valve *G* to provide for the admission of air into tube *D* at the proper time to eject the work. Such an apparatus can be worked very rapidly.

Multiple-spindle Drilling Machines of Cluster Type

Machines which will be discussed under this heading may be roughly sub-divided into standard and special equipments. Standard multiple-spindle drilling machines are built by several firms and are practically universal in their application, in so far as drilling holes over an area within their range is concerned. The only limitation in the use of these machines is in regard to the minimum distance between centers of different holes that must be drilled. As compared with this condition, we have the special-purpose multiple-spindle drilling machine, which is adapted for the performance of one specific manufacturing operation; machines of this type are being used to extremely good advantage in the performance of drilling operations on automobile crankcases, etc., but it necessarily follows that a plant that can afford to buy a single-purpose multiple-spindle drilling machine must have a large volume of work in order to be able to earn a fair return upon the investment. After reading the following description of operations performed on machines of each type, the reader will have a good idea of the scope of work that comes within the province of the cluster type multiple-spindle drilling machine.

Fig. 19 shows one of the No. 14 "Natco" multiple-spindle drilling machines built by the National Automatic Tool Co.; this machine is used at the plant of the Willys-Overland Co. for drilling and reaming one hole 3/4 inch in diameter by 1⅝ inch deep and two holes 5/8 inch in diameter by 1 inch deep; in addition, four 17/64-inch holes, 7/32 inch deep, are drilled in the flange of the rear axle spiders, but these holes are not reamed. This installation is somewhat exceptional in that it involves the use of an indexing fixture on a multiple-spindle drilling machine. This fixture is furnished with three stations, one of which is a loading station; at one station the three large holes are drilled and two of the 17/64-inch holes are also drilled, and at the third station the three large holes are reamed while the other two 17/64-inch holes are drilled. Evidently this calls for the use of a ten-spindle drilling machine with the spindles arranged in two groups of five spindles each. In the first group there are one 3/4-inch drill, two 5/8-inch drills and two 17/64-inch drills; in the second group there are one 3/4-inch reamer, two 5/8-inch reamers and two 17/64-inch drills. The arrangement of these holes in the work will be apparent after studying the piece shown lying at the base of the machine just under the fixture. The 3/4-inch hole is shown at *A*, the two 5/8-inch holes at *B* and the four 17/64-inch holes at *C*.

The preceding description has explained the manner in which the indexing fixture carries the work under the two groups of spindles in order to provide for drilling and reaming three holes, and drilling four other small holes. The arrangement of this work-holding fixture is quite interesting. A pilot carried on pivoted bar *D* enters the hole in the lower end of the work and raises the work so that a pilot carried by frame *E* enters the upper end. After the pivoted bar *D* has been clamped by T-screw *F*, the work is secured in the fixture, as regards its vertical position. It is still necessary, however, to locate the work about its vertical axis so that all seven holes *A*, *B* and *C* will be properly positioned in the spider. This is accomplished by a sliding V-block, which is pushed over the end of the work adjacent to the 3/4-inch hole *A* by means of screw *G*. Of course, there are three complete sets of mechanism corresponding to each of the three stations on the work-holding fixture, and for each traverse of the multiple-spindle drill head, one spider is finished, so that the operator may remove one piece at the loading station and substitute a fresh blank. These spiders are made of malleable iron and the rate of production is 960 pieces per eight-hour working day. Owing to the length of time required to load pieces into this fixture, the speed and feed at which the operation is performed is less than would ordinarily be employed

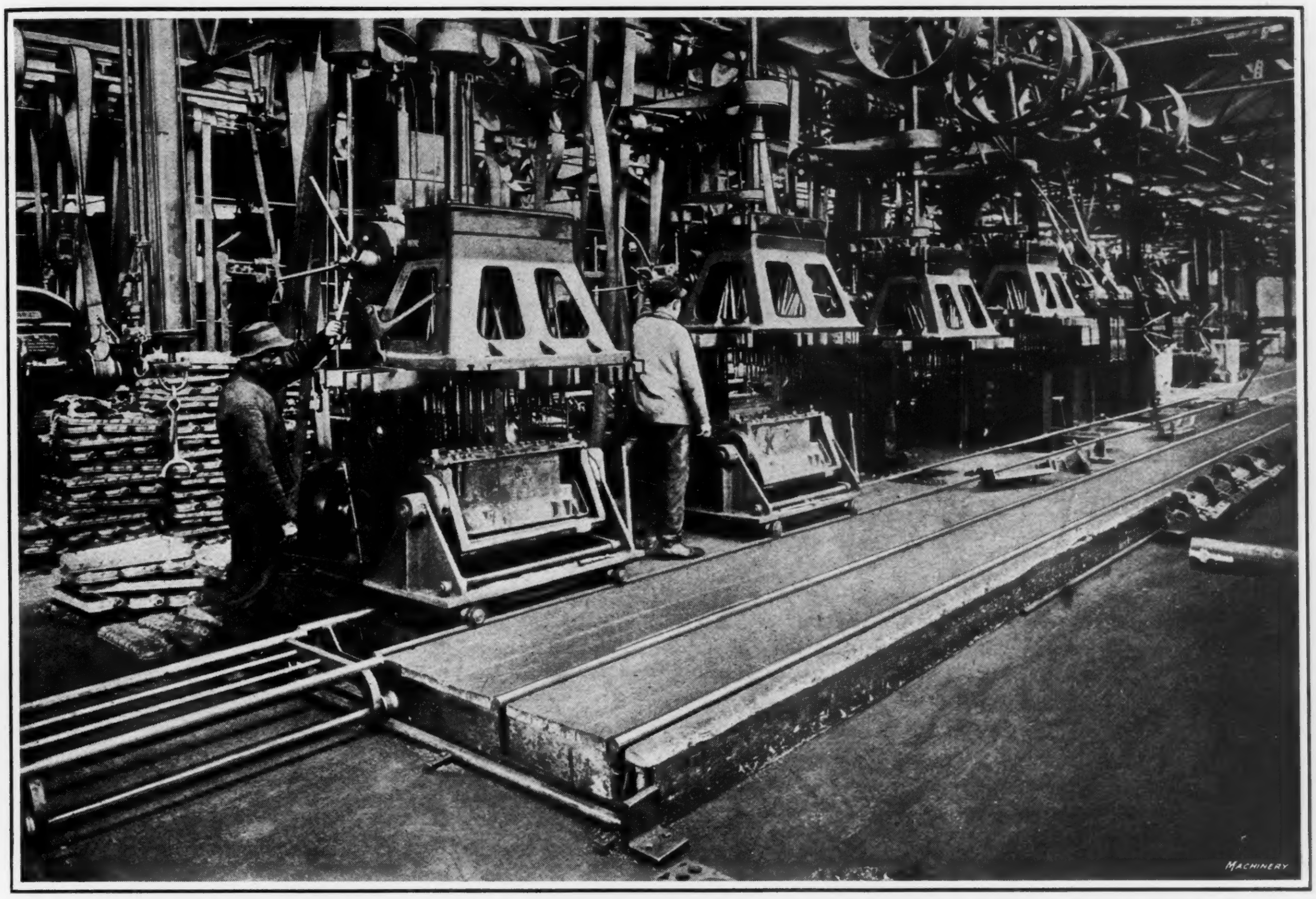

Fig. 21. Traveling Jigs used in Connection with Multiple-spindle Drilling Machines built by Baush Machine Tool Co. for machining Automobile Engine Cylinder Blocks

for drills and reamers of these sizes. This loss is partially offset by the fact that more parts are obtained for each grinding of the tools.

At the plant of the Continental Motors Co. there is an extremely interesting equipment of multiple-spindle drilling machines built by the Baush Machine Tool Co. These machines are used for the performance of drilling operations on the engine cylinder blocks, and to facilitate handling of the work as far as possible, an interesting arrangement of traveling jigs has been developed. Reference to Fig. 21 will show that each of these fixtures is carried on a truck running on tracks that pass along under the heads of the multiple-spindle drilling machines. The jigs are supported on trunnions in the truck frames, which make it possible to swing the work around to provide for the performance of drilling operations in different planes on the work. Each drilling machine is equipped with a cluster head in which the spindles are grouped to provide for simultaneously drilling all of the holes in one face of the cylinder block. After the groups of small holes have been drilled, the work goes on under straight-line multiple-spindle drilling machines which provide for drilling the valve-stem holes, valve push-rod holes, etc. The work is then removed from the jig and the empty truck is run onto a section of track, which, in turn, is supported on truck wheels so that the track may be moved over into alignment with the return track rails, which will be seen in the foreground of the picture. As the truck jig moves down this track a new casting is put in place, after which the jig is moved along onto a second transfer truck on which it is moved over to the rails which will carry it under the drilling machines for the performance of successive operations. With this arrangement it is possible to employ a sufficient number of reserve jigs, so that work may be constantly available for the machines as fast as they complete operations on a given cylinder block. Consequently idle time of the machines and operators is reduced very close to the absolute minimum.

Fig. 20 shows another application of a Baush multiple-spindle drilling machine on cylinder block work. In this case the machine is employed in the plant of the Lozier Motor Co., and the arrangement of work-holding fixture and jig-plate bring out two principles which are of interest. In the first place, the base *A*, on which the work is supported, is mounted on ways which enable it to be slid out from under the multiple-spindle drill head to provide for the convenient removal of drilled work and substitution of a fresh casting. The other point of interest in connection with this job is the use of a jig-plate *B*, which is secured to the work to provide for maintaining a positive relation of the drills to one another. This idea of employing a jig-plate which is secured to the work, instead of having the jig part of a work-holding fixture which carries the piece to be drilled, may be employed in many cases with very satisfactory results.

The next installment will take up single-purpose cluster-type multiple-spindle drilling machines, station-type machines, applications of inverted drilling principle for deep-hole work, machining shells on drilling machines, auxiliary drilling heads and speeders, automatic and semi-automatic drilling machines, etc.

* * *

MEN REQUIRED FOR MECHANICAL WORK ON AIRPLANES

In order to further extend the aviation branch of the U. S. Navy, Secretary Daniels has authorized the enlistment of 8000 men for mechanical work on airplanes. These men will not be enlisted for pilot's duties, but, coming into the service as mechanics, will receive a special and unusual training in the building, handling, repairing and overhauling of aircraft, and will be the ground personnel of the flying corps. The requirements for enrollment will be the same as for the regular service in the U. S. Navy, the enlistment being as machinist's mate. The training will last about three months, and on the completion of the training course, those who pass the examination will be rated as first- or second-class petty officers, and will be eligible for promotion to the next higher grade if they show fitness, the promotion in the aviation field being unusually fast. The age limit for enlistment is from 21 to 35 years. Besides machinists, coppersmiths, blacksmiths, acetylene welders, gas-engine repair men, instrument makers and electricians are wanted. Machinists who have had previous experience in gasoline engines or in any similar skilled trade will have preference. Applications should be sent to the U. S. Navy Recruiting Bureau, 318 W. 39th St., New York City.

GRINDING MACHINE TOOL PLANE SURFACES

Milling machine tables may be finished at low cost by grinding the top on a surface grinding machine after the slide has been scraped and finished. The resulting surface is true, hard and smooth, and well fitted for long wear. Not only is the finishing by grinding an economical practice, but it gives a pleasing effect of material advantage in selling the machine.

The grinding of plane surfaces on machine tools is being developed still further, and it would not be at all surprising to find some enterprising machine tool builder who has developed a method of grinding lathe ways and thus eliminated the slow, laborious and costly job of fitting and scraping. A ground lathe bed should be superior to a scraped bed both as regards accuracy and durability. No one questions the accuracy of a ground surface. It is easy to produce plane surfaces true within limits of $\pm$ 0.00025 in a length of 18 inches, and, in fact, closer limits can be worked in actual practice. Another advantage of great importance on a lathe bed is that the ground surface is hard and dense, and in first-class condition to resist long wear. Any fitter who has tried to scrape a ground cast-iron surface knows how hard and dense the surface is when ground. Unfortunately, lathe designers have not yet been able to design an engine lathe in which the ways—the vital working surfaces—are fully protected from cast-iron dust and its abrading action. The ground chilled vee is a partial solution of the problem.

LOCK KNOB DIES

BY W. B. GREENLEAF [1]

In Fig. 1 are shown the four stages in the process of transforming the stamping *A* into the lock knob *D*, which is invariably taken to be a drop-forging. As the ball is stamped from 1/8-inch stock and the outside diameter is 1/2 inch, the inside diameter is, approximately, only 1/4 inch; consequently the area of the outside of the ball is four times as great as the inside, and as these two sides are about the same in the blank *A*, it is necessary to compress one face and stretch the other. This stretching and compressing of the metal must be done in the second operation. If any of it is done in the third, the punch, which is only 1/4 inch in diameter, will push through the metal; if any of it is done in the fourth operation, a fin will be squeezed out between the upper and lower dies. On the other hand, it can easily be done in the second operation, because the piece is flat and can be worked on both sides by the punch and die; besides, it can be enclosed and kept from flowing out of bounds. The process of making this knob was developed only by spending considerable time experimenting, for a slight variation in the blank changes the result. For working purposes, the finished ball is considered as being divided into five sections. The largest of these is approximately a half ball and handle, or shank, as shown at *B*, Fig. 2; the other four are triangular sections, shown at *B* and *C*, Fig. 1, each of

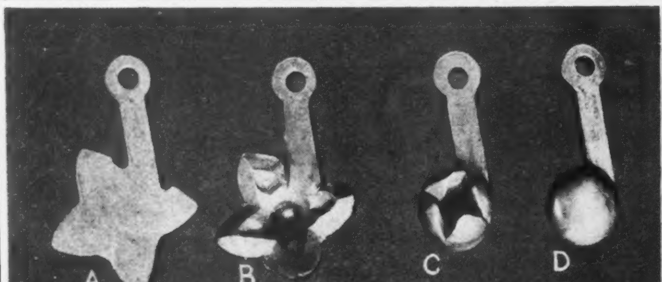

Fig. 1. Four Stages in Manufacture of Lock Knob

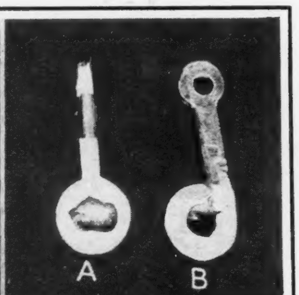

Fig. 2. Sections through Finished Knob

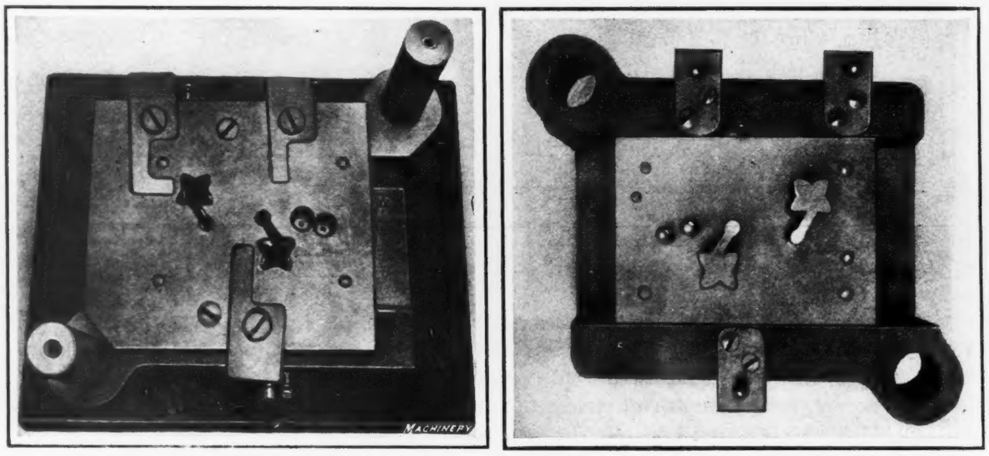

Fig. 3. Die and Punch for making Stamping

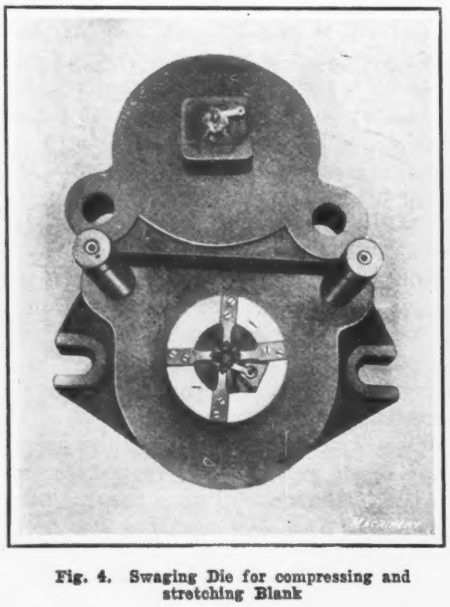

Fig. 4. Swaging Die for compressing and stretching Blank

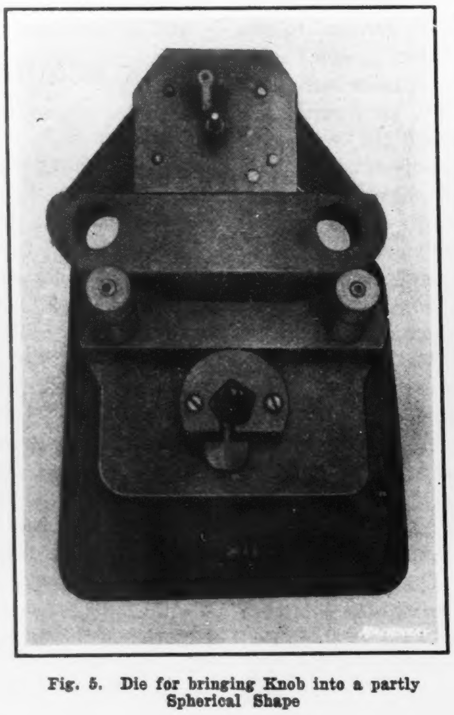

Fig. 5. Die for bringing Knob into a partly Spherical Shape

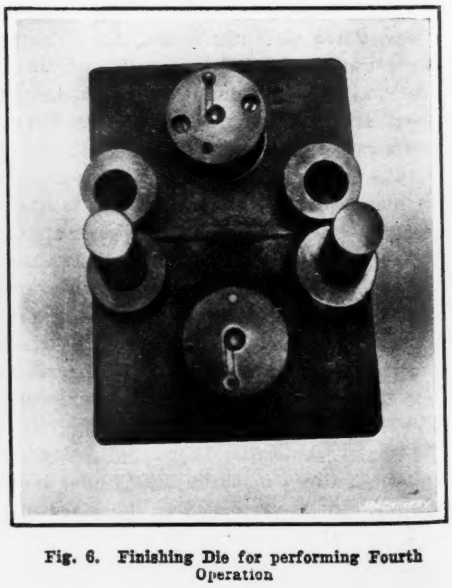

Fig. 6. Finishing Die for performing Fourth Operation

[1] Address: Plymouth, Mich.

which forms about one-eighth of the finished ball. At *A*, Fig. 2, is shown a section through the ball at right angles to the section shown at *B*.

The success of the whole process depends on the results obtained in the second operation, in which the flat blank *A*, Fig. 1, is swaged into such a shape *B* that it may be transformed into a ball in the following operations without much pressure. In this operation, each of the five sections of the ball is correctly formed, but the sections are left spread out, as shown. However, as the metal still has a tendency to back up in the final rounding, in the third operation, the diameter is reduced 1/32 inch to allow for this and prevent a fin.

The dies used are shown in Figs. 3, 4, 5 and 6. The blanking is done on a gang follow die, shown in Fig. 3, the two pieces interlocking to save metal; as shown by Fig. 7, there is little waste. No pilots are necessary, as a large variation is allowable in the position of the small hole. In a follow die of this kind, there is likely to be considerable waste from bad pieces at the beginning of each strip, unless some sort of positive stop is used at the first, second and third stages. Of course, any of several styles of temporary stops may be used, but they all have disadvantages. In this die, three automatic trigger stops are hinged about flush with the top of the stripper; this increased the first cost, but the plan worked so well that the same scheme has been used on several similar dies. The operator is thus relieved of all trouble, and can run the strip against the first stop and, after the press is tripped, the strip will go right through without stopping to the end, and all the blanks possible will be made from this strip.

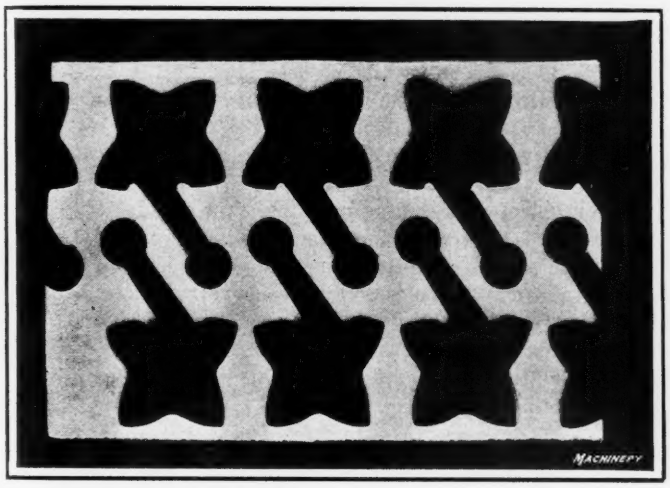

Fig. 7. Strip showing Waste left by Stamping

The punch in the third operation, shown in Fig. 5, enters a seat made in the piece in the second operation, which locates it exactly and keeps it central during the bending. The face of the die is worked out to fit the piece, and the opening has a long gradual taper at the mouth to make the bend as easy as possible. A positive ejecting pad, not shown, is joined to the punch-holder by a yoke and rods. In the fourth, and final, operation, the piece is located by the shank, and a spring pin in the punch shown in Fig. 6 strikes the end of the shank first and keeps the points upright so that they will enter the upper form. *A* and *B*, Fig. 2, show how effective is the closing.

MILLING RELIEF IN KNURLS

At the Frankford Arsenal use is made of the type of knurl shown at *B* in Fig. 1. These knurls are made of high-speed steel, and the first operation consists of setting the blanks up on a gear-cutting machine to provide for cutting the teeth. After this operation has been completed, the condition of the work is that shown at *A* in Fig. 1. A concern which had a contract to furnish the government with a large number of knurls of this type experienced trouble in milling the relief. This matter was mentioned to the management of the T. C. M. Mfg. Co., Hunterdon and First Sts., Harrison, N. J., with the result that this firm undertook to mill the relief on a contract basis. For this purpose a T. C. M. thread milling machine was set up as shown in Fig. 2. Here it will be seen that the work *A* is mounted on an arbor in the spindle which is driven by pulley *B*, power being transmitted through a worm on the pulley shaft to worm-wheel *C*, which is keyed to the spindle. It will be seen that milling cutter *D* is driven by an independent belt on pulley *E*, from which power is transmitted by a silent chain drive to sprocket wheel *F*, keyed to the rear end of the cutter-spindle.

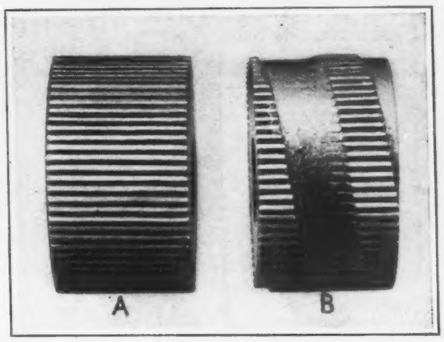

Fig. 1. Knurl before and after milling Relief

In handling this milling operation, the cutter-head is set at such an angle to the work-spindle that the helical relief will be milled as the work is fed past the cutter. In order to obtain this result, provision is made for setting the cutter-spindle at the required angle to the work-spindle, and also to feed the work past the cutter. This feed motion is obtained by having the work-spindle designed to move longitudinally in its bearings as feed motion is imparted to the spindle by worm *G*, which runs in a half-nut carried in a bracket bolted to the bed of the machine.

Attention is called to the half-nut engaging worm *G* and the head carrying the cutter-spindle, which are arranged on slides, so that the half-nut and cutter may be dropped out of engagement with the worm and work, respectively. This result is obtained by having a trip arranged on the work-spindle in such a way that when this spindle has been advanced to a point where the milling operation has been completed, the trip engages a dog carried on horizontal shaft *H*. Engagement between this trip and dog results in turning shaft *H;* and this shaft carries two cams which hold the nut in contact with worm *G* and the cutter-spindle head in its upper position. Hence, turning shaft *H* allows disengagement of the half-nut and cutter, respectively. The work is then removed from the machine and the work-spindle pushed back to the starting point, after which a hand-lever is used to swing shaft *H* back so that the cams carried by this shaft will raise the half-nut and cutter into their working positions. After a fresh piece of work has been set up, the machine is ready to be started. Eighteen knurls are milled per hour, the rate of production being kept down by the hardness of the steel and by the small size of the hole, which is only 5/16 inch in diameter. E. K. H.

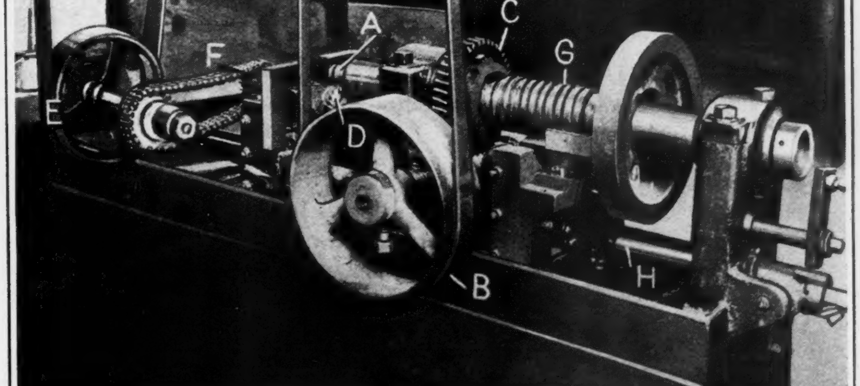

Fig. 2. T. C. M. Thread Milling Machine set up to mill Relief in Knurls

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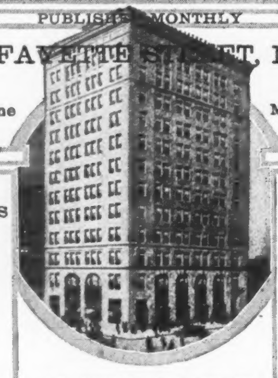

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DRILLING PRACTICE

Drilling holes is the most common machine shop operation, and the drilling machine the most common of machine tools. Even a blacksmith shop has some sort of drilling machine, and in hundreds of small shops the drilling machine is the only machine tool provided. Drilling or boring a hole in wood and stone is essentially a primitive operation that was practiced by the human race before the dawn of history. In this age of manufacture the production of holes runs into millions daily.

The development of high-speed steel has made a great change in drilling practice as in other metal working with machine tools. High-speed drilling machines have been greatly improved as regards dynamic balance, those capable of driving a 1/32-inch drill at a cutting speed of 80 feet per minute being dynamically balanced and provided with bearings offering a minimum of frictional resistance.

War needs must be supplied quickly, and rapid drilling of motor parts is necessary for the rapid production of the great number of engines needed for motor trucks and airplanes. The multiple-spindle drilling machine is a most important factor, and so highly are these machines developed that all the holes in a crankcase numbering more than one hundred are drilled in a minute, thus making the drilling production on crankcase work to exceed five hundred in a nine-hour day. This remarkable result is obtained on a high-grade machine tool, strictly interchangeable throughout, the parts being standardized in units, and the gears and shafts being hardened and ground. The time when a drilling machine was a cheaply made tool is past, especially for rapid production work. Only the best design and construction will stand the strain of such intensive work.

In drilling practice everything depends on the drill point, and more trouble is due to improper drill grinding than to any other cause. Because of its simple character, the drilling machine is commonly operated by men of little or no mechanical training, who have but a moderate comprehension of the principle of metal cutting, and if required to keep their drills sharp, they are likely to produce some harrowing examples of drill grinding. The result is broken drills, inaccurate holes, slow production, broken feed gears and many other troubles that are caused solely by dull and improperly shaped points. It is hardly possible to exaggerate the importance of correct drill grinding. It means longer life for the drill and the machine, better work, less lubricant consumption and greater efficiency all along the line. Drill grinding is too important a tool-sharpening operation to be entrusted to the ordinary run of operators. That practice is uneconomic and wasteful. Drills should be ground by experts and furnished to the operators ready for use. This is an established fact, but, unfortunately, one not generally practiced.

* * *

MACHINERY FOR CRIPPLED SOLDIERS

Although machinery is designed for operation by normal men and not by cripples, and much has been done to simplify its operation, the designer has always had in mind operators with both hands and feet. The war is making an enormous number of cripples who must be provided with ways and means of earning a living. A percentage of those cripples who before enlisting were working in machine shops, because of their disability, will be unable to continue their vocations unless means are provided that will enable them to produce at least an average day's output. We suggest that machinery be designed with simple auxiliary control devices which will enable men who have lost their hands to work the levers by their feet. Electrical control probably offers the best solution, as push-buttons that may be worked by either foot or by an arm stump could be readily adjusted to suit the convenience of almost any cripple who is able to move himself about. The development of electrical control along these lines would be a step toward making machinery more efficiently operated by normal workmen generally.

The problem of designing machinery for the use of cripples will never be of greater importance than now; and it should receive immediate attention from designers, because the number of industrial cripples created each year is great, and the number created by the war will be enormous. Machinery should be so designed that the industrial as well as the war cripples will be able to continue earning an honorable and self-respecting livelihood.

* * *

GAGING AND INSPECTION OF MUNITIONS

There was considerable discussion on the subject of gaging and inspection of munitions at the last annual meeting of the American Society of Mechanical Engineers, but except for the resolution which was passed recommending that the Bureau of Standards be designated as a central bureau for verifying and certifying all gages used in the carrying out of government contracts requiring accurate measurements, the discussion brought out but few definite and conclusive ideas. There are two general and fundamental principles which, if suitably recognized and applied, would eliminate much confusion and most of the criticism to which the Ordnance departments have been subjected on account of the methods they have pursued and the inspectors they have employed. The first of these principles is that as great tolerances as possible should be permitted in every case, the only limiting condition being that the parts should properly fill the function for which they are designed. The widest permissible limits in dimensions make for economical manufacture and rapidity of production—two factors of the highest importance in the making of war materials. It is the general belief that the Ordnance departments demand too close limits, and in many cases it is well known that the drawings call for an excessive degree of accuracy where it is of no practical importance and only increases the expense of manufacture.

When the widest possible tolerances have been allowed, the second principle—that of providing gages so designed and having themselves such limits of accuracy as to make their manufacture a simple commercial proposition—is comparatively easy to apply. The degree of accuracy of limit gages, for example, need not be as great where large limits are allowed on the work and where the tolerances are small. The tolerances on the gages themselves should be a certain percentage of the total tolerance in the work, and, furthermore, the working gages should be so designed that any part that

is correct according to the working gage passes the inspection gages without question. In other words, the working gages should allow slightly smaller tolerances than the inspection gages.

These two main principles having been correctly worked out, all other questions connected with the inspection of machine parts become merely a matter of detail and routine. Of course, the inspector requires a certain amount of judgment, but by the use of proper gages the need for the exercise of this faculty may be reduced to a minimum. It is, however, highly desirable that when close limits are required on work that may seem of little importance to the mechanic not familiar with the construction or purpose of the product, the specifications should state the reasons for requiring a highly accurate finish, as this would help to create a proper attitude of mind toward the work on the part of all concerned. As an example, it may be mentioned that shell manufacturers thought the high finish required on the inside of the shells a mere fad, when, in practice, it has been found that rough shell interiors may cause premature explosion, due to the friction set up in the revolving shell between the bursting charge and the walls, which may, with rough walls, create enough heat to ignite the charge. The Russian shell specifications sent to this country in the early part of the war contained explicit directions and explanations, making it possible for the manufacturer not only to understand the mechanism, but also to see the reasons for many of the peculiar requirements.

* * *

COST PLUS TEN PER CENT

In order to avoid paying exorbitant prices for war materials ordered by the government, a policy was adopted almost immediately after the United States entered the war to pay manufacturers undertaking contracts for the government on the basis of cost plus a percentage. The percentage differs according to the trade and conditions, being adjusted in each case to what is assumed as a fair profit.

Theoretically, this is a very good arrangement, and was entered into by the government officials with the best of intentions; but, unfortunately, it has not worked out as satisfactorily in practice as was at first expected. As the contractor's profits are based upon his costs, it is not to his interest to keep costs down, for in so doing he also keeps his profits down. It has been observed by people who have seen this principle in practice that it does not work to the advantage of the government, and that enormous amounts are wasted, because it is not to anybody's direct advantage to keep costs down. It has been stated, for instance, that workmen engaged in building cantonments took life very easy, and the contractors did not interfere for the simple reason that their profits rose with the rising costs to the government. It has been rumored that similar conditions exist in other industries.

MACHINERY ventures to suggest to the earnest men who place government contracts that it should be practicable for them to so arrange the cost-plus-percentage plan that it would be to the interest of the contractor as well as the government for him to keep his costs down. Assume, for example, that at the outset a maximum fair price be determined as nearly as possible, the contractor to be allowed, say, 10 per cent for profit (or whatever percentage is deemed fair); now stipulate that for every 5 per cent the contractor saves the government on this estimated cost, he be allowed, say, 2 per cent extra profits. On the other hand, for every 5 per cent that he exceeds the stipulated cost, he loses 2 per cent; in other words, if the actual cost of a contract were estimated at, say, one million dollars, the contractor's profits would be 10 per cent, or \$100,000. If the contractor could cut the cost 20 per cent, or to \$800,000, his profits would be 18 per cent of \$800,000, or \$144,000. But if his costs went up to \$1,100,000, his profits would be cut to 6 per cent of this amount, or to \$66,000.

It is quite evident that under such an arrangement it would be to the interest of the contracting manufacturer to keep his costs down, because the lower the costs the greater his profits. On the other hand, if he could not keep his costs within the predetermined fair figure, it is quite equitable that he should share some of the loss with the government in the form of decreased profits, as the government would have to pay the lion's share of the increased cost.

Of course, the foregoing figures and percentages are stated as examples only, to illustrate the principle, which, if adopted, would doubtless overcome the evil tendencies of the straight cost-plus-percentage principle. With business men acting on so many of the advisory boards at Washington, we believe that some such arrangement will soon be adopted to meet the criticisms directed against the straight cost-plus-percentage method of letting contracts.

The straight cost-plus-percentage plan gives an undue profit to the inefficient, careless or unscrupulous contractor, while it penalizes the efficient, honest and painstaking concern. The proposed differential cost-plus-percentage plan would place a premium on ability and integrity. It would encourage contractors and manufacturers to develop efficient organizations, to employ labor-saving methods, and to work under the conditions of high-pressure efficiency that are necessary to win the war, and to win it without needless cost in men and wealth.

* * *

GAGE COMMITTEE OF A. S. M. E.

A committee was appointed at the spring meeting of the American Society of Mechanical Engineers held in Cincinnati, Ohio, in May, 1917, to take up the question of securing uniformity in gages used in the manufacture of all kinds of war material ordered by the government from private manufacturers. This committee presented a report at the annual meeting of the society in New York, and a public hearing was held by the committee on December 4 at the Engineering Societies' Building. At the meeting a resolution was passed embodying the principle that the American Society of Mechanical Engineers recommends that all master and reference gages and standards of measurements used in the manufacture of war materials be certified by the Bureau of Standards, as in this way there would be one central bureau or place where all gages could be compared with accurate standards. It was recommended that a clause to this effect be inserted in all contracts placed by the Ordnance Departments, and incorporated in all specifications for work that requires accurate gages, and that all the gages used by the various government bureaus also be certified in the same manner. It is not the intention to make the Bureau of Standards responsible for the limits set, but merely to have the Bureau certify that the gages submitted are made according to the limits prescribed in the specifications.

It was evident that considerable interest and importance is attached to this method by both the government and manufacturers of gages and war materials. The hearing was well attended, there being present, in addition to many members of the society, a number of officers representing the government and the Ordnance Department, members of the British Ministry of Munitions in the United States, representatives from the Canadian Munition Board, and a number of the leading manufacturers of gages, munitions and other war materials in the United States. An interesting point brought out by one of the speakers familiar with the manufacture of rifles and ammunition was that the cost of inspecting small arms, ammunition and rifles was about equal to the actual cost of manufacture. The great importance of proper gages and gaging methods was emphasized, and it was suggested that no greater service could be rendered at this time than the spreading of information relating to proper gaging methods, properly constructed gages and the principles generally involved in gaging and inspection.

* * *

Sheet lead may be used for making a small pattern in a hurry when a casting is wanted for experimental purposes. The lead can be easily cut and formed by hand to any required shape and soldered at the joints to hold the pieces together. By the judicious use of iron rods or pipe to reinforce and hold the shape, long slender patterns can be made in this manner and pressed sheet tin pans and other hollow metalware may be used also to build up a fairly complex form of considerable size. The result may not be pretty, but it often serves the purpose when time and cost are important considerations.

WELDING TRANSFORMER TANKS BY THE ELECTRIC ARC PROCESS

METHODS DEVELOPED BY THE PITTSFIELD WORKS OF THE GENERAL ELECTRIC CO. IN THE MANUFACTURE OF ELECTRIC TRANSFORMER TANKS

BY ERIK OBERG [1]

THE electric arc-welding process, the general principles of which were outlined in an article in the December, 1917, number of MACHINERY, has been developed and applied to a great extent in the welding of seams in transformer tanks at the Pittsfield Works of the General Electric Co. The method has been found superior for this work to all other methods used or investigated by the company. At one time, many of the transformer tanks were riveted; this was more expensive and less satisfactory than the welding on account of the fact that it was difficult to obtain absolutely leakproof tanks by the riveting process, oil having a tendency to seep through even the most minute openings. In its efforts to obtain a better method than riveting, the company used the oxy-acetylene method to a large extent for several years. This method had the advantage of producing satisfactory oil-tight welds, but was found to be quite costly. In an effort to reduce the manufacturing cost, electric arc welding was tried and found to meet the requirements, producing a satisfactory weld at a decreased cost; hence practically all the sheet-metal transformer tanks made at the Pittsfield Works are now welded by the electric-arc method. In addition, the electric arc is used on miscellaneous welding about the plant.

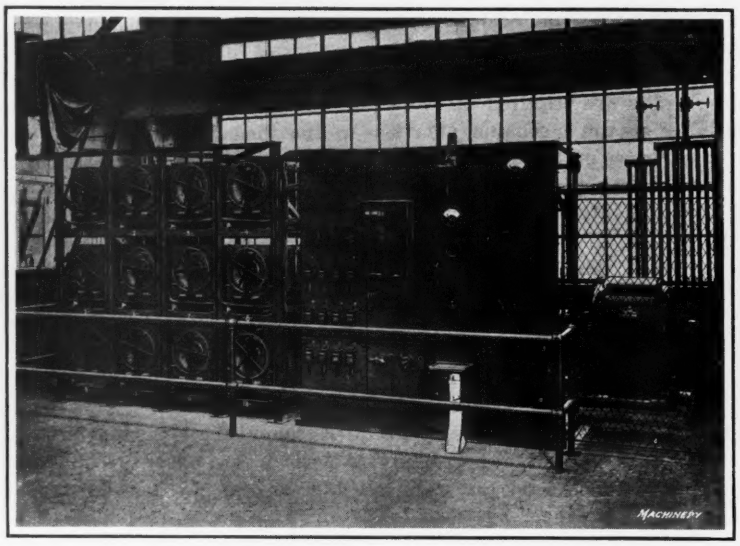

Fig. 1. Welding Equipment, showing Part of Generator Set and Switchboard

Welds are made in metal varying all the way from 1/16 to 3/4 inch in thickness. Steel plate as thin as 1/16 inch is lap-welded, and butt-welds may be made in metal as thin as 1/8 inch. Thin metal like this requires no beveling at the edges of the sheet preparatory to welding. If metal thinner than 1/16 inch is to be welded, the arc process is found unsuitable, because the arc will burn the metal. When metal from 1/4 to 5/8 inch in thickness is welded, it is beveled on one side, and steel plate 3/4 inch or more thick is beveled on both sides when seams are made. When used against the transformer shell for a bottom, it is beveled on only one side. Transformer tanks from the smallest size up to those 10 feet in diameter and 14 feet high (the latter being made from 5/8-inch boiler plate) have all their longitudinal seams welded in this manner, and the sheet-steel rim at the bottom is also welded to the tank by the electric arc. Cast-iron bands at the top of some transformers cannot be welded to the cylindrical steel shell, but must be riveted or joined by bolts; but the arc-welding process is used for welding around the heads of the rivets or bolts on the inside of the tank in order to insure that there will be no leakage at those points.

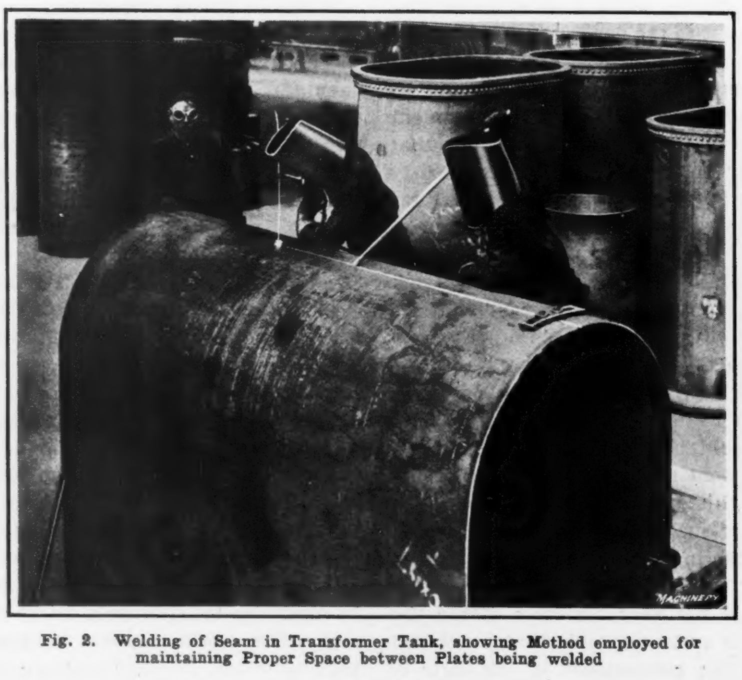

Fig. 2. Welding of Seam in Transformer Tank, showing Method employed for maintaining Proper Space between Plates being welded

[1]Associate Editor of MACHINERY

Equipment Used for Welding

The equipment used for welding in the Pittsfield plant consists of a motor-generator set which generates 75 volts direct current. The capacity of the generator is 150 kilowatts; it is driven by a 225-horsepower induction motor supplied with 60-cycle alternating current. The direct current from the generator passes to direct-current busses on which a constant voltage is maintained by a voltage regulator. Attached to the busses are twelve separate welding circuits, so that each welder can work independently. On the switchboard panel, shown in Fig. 1, twelve rheostats are mounted together with the remote-control switches in series with each welding circuit, so that the welder does not need to leave the place where he works in order to control the current. In series with the rheostats is a reactance coil, the object of which is to maintain the arc if drawn out too far, and also to reduce the rush of current when striking the arc. All this apparatus is mounted on or adjacent to the main switchboard and the generator set.

On the floor where the welding is done, separate stations are provided, with one panel for each welder. These are placed adjacent to the spot where the work will be done. From these panels the welder adjusts the current, as indicated by the ammeter mounted on the panel. A plug is provided which is pulled out when the operator is not working. On the holder for the electrode, a switch is also provided which may be snapped to open or close the circuit.

Electrodes

The electrodes for welding sheet steel and boiler plate, used in the construction of transformer tanks, are bought in the form of wire coils or rolls, from which the electrodes are cut off in lengths of about 18 inches, and straightened. Swedish iron wire is used for this purpose, when obtainable, but similar wire, known as "Toncan wire," is also obtainable in the United States, the Pittsfield Works obtaining their supply from the Washburn Wire Co., Phillipsdale, R. I. The wire comes in sizes of from 1/16 to 3/16 inch in diameter. The carbon electrodes used for certain work are tapered in shape, being about 1/8 inch in diameter at the small end, and 3/8 inch at the large end. The length is about

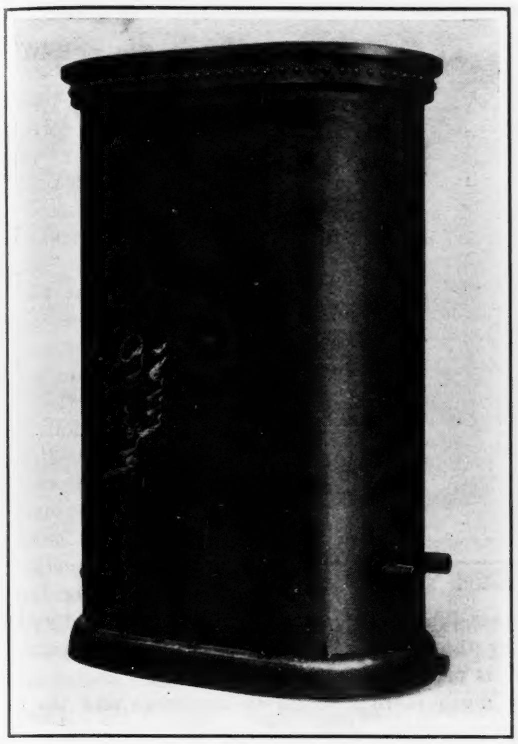

Fig. 3. Base of Tank with Space between Base and Shell and Spot-welds holding Base and Shell together

Fig. 4. Arc Welding of Corrugated Sheet Steel for Small Transformer Tanks, using Carbon Electrode

5 inches, when new. When used, the carbon electrode gradually burns away, but, being tapered, it maintains practically the same diameter at the point as it diminishes in length. The carbon electrodes are made from a composition similar to that from which arc-lamp carbons are made. Graphite electrodes may also be used, but they do not last such a long time as do the carbon electrodes.

Protection of Welders

The welders wear a hood, as shown in Fig. 2, to protect their heads from the rays from the arc and their eyes from the intense light, and also gloves to protect their hands from burns. The glass in the welding hood consists of three thicknesses: one medium green glass, one dark red glass, and one plain white window glass. The latter is placed outside of the colored glass, the object being to protect the colored glass from the deposit of atomized metal which, during welding, gradually settles on the glass. The piece of plain glass, when useless on account of these metal deposits from the arc, can be replaced at a low cost.

DATA FOR BUTT-WELDING OF SHEET METAL BY THE ELECTRIC ARC (METALLIC ELECTRODE)

Thickness of Metal, Inches	Diameter of Electrode, Inches	Speed per Hour, Feet	Amperes			Mean K.W. at 60 Volts	Mean K.W. at 70 per Cent Efficiency	Electrode Used per Hour, Pounds	Cost of Power per Hour, Cents	Cost of Electrode per Hour, Cents	Total Cost per Hour, Cents[1]	Total Cost per Foot, Cents
			Low	Mean	High							
1/16	1/16	20.0	25	30	40	1.8	2.6	0.9	7.8	4.5	42.3	2.12
1/8	1/8	16.0	30	50	75	3.0	4.3	1.4	12.9	7.0	49.9	3.12
1/4	1/8 or 3/16	10.0	70	100	125	6.0	8.6	3.1	25.8	15.5	71.3	7.13
3/8	3/16 or 1/4	6.5	100	125	150	7.5	10.7	3.6	32.1	18.0	80.1	12.30
1/2	1/4	4.3	120	140	175	8.4	12.0	3.8	36.0	19.0	85.0	19.80
5/8	1/4	2.8	125	155	195	9.3	13.4	3.4	40.2	17.0	87.6	31.30
3/4	1/4	2.0	125	160	200	9.6	13.8	2.4	41.4	12.0	83.4	41.70
1	1/4	1.4	125	160	200	9.6	13.8	2.7	41.4	13.5	85.9	61.30

Machinery

[1] Labor estimated at 30 cents per hour

Preparation for Welding

Comparatively little preparation is required for the welding of sheet metals. In the case of thin metals, the pieces are merely held together by suitable clamps and lightly tapped with a hammer so that they will fit properly. In the case of long welds, it is necessary to separate the plates slightly, previous to welding, because of the expansion that takes place during the welding operation. The usual method is to separate the plates 1/8 inch at the end where the weld is to begin, and to increase the space between the edges of the plates at the rate

Fig. 5. Tank with Six Seams that were welded by Electric Arc-welding Process

Fig. 6. Inside View, showing Metal forced through Seam and Reinforcement at End of Seam

of 2 per cent of the length. It has been found that, by placing the plates in this position, they will come together as the weld proceeds along the seam. As already mentioned, thin work is not beveled or prepared in any way, while thick plates are beveled on one or on both sides.

In Fig. 2 is shown a longitudinal seam of a tank being welded. As indicated, the plates are held apart by a clamp and bolts at one end of the seam, while the welder works from the other end. An assistant holds the plates apart a short distance from the weld with a bar as shown. In Fig. 3 is illustrated the base of a tank prepared for electric arc welding. A space is left between the tank itself and its base, but spot-welds are provided along the edge of the shell for holding the base and shell together during the arc welding.

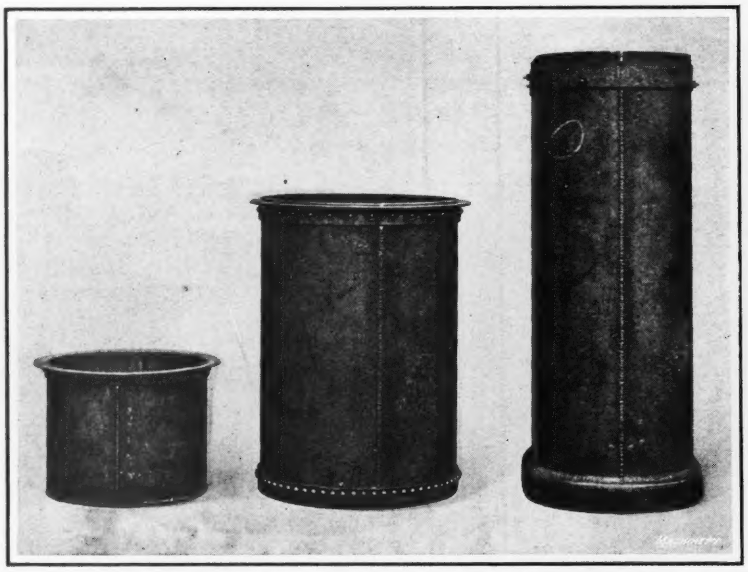

Fig. 7. Tanks welded by Electric Arc, using Metallic Electrode

Welding Operation

The welding operation is comparatively simple, and operators can be taught to become proficient in a comparatively short time. The best welders are those who have had previous experience with oxy-acetylene welding. They will learn to do good arc welding in about four weeks, but a "green" man will require from eight to ten weeks to become proficient. It is somewhat easier to manipulate the carbon arc than the metallic arc, on account of the fact that the former is longer and does not break as easily if the operator does not hold his hand steady. The arc, while welding by the metallic electrode, is not more than 1/8 inch long, and it requires considerable practice to move the electrode steadily along the weld without either touching the work or bringing the electrode so far away from the work that the arc is broken. The metallic arc is used for welding practically all the sheet-metal work that is butt-welded, and most of that which is lap-welded. The carbon arc is used only in the case of welding thin sheets of corrugated metal used for smaller transformer tanks. In that case, sheets from 1/16 to 3/32 inch in thickness are fitted together, side by side, so that the edges of both sheets face upward, as shown in Fig. 4. The carbon electrode is then moved along the joint, melting the metal at the edges and welding or fusing together the two sheets without using a welding rod or supplying any additional metal. The reason for using the carbon arc is that the metal is melted much more rapidly in this way than by the metallic arc, but, for general welding, the metallic arc is preferred, because it produces a neater job, the seam being much more uniform in thickness and the metal deposited more evenly. Most of the welding is done by hand, but special welding machines have been developed, in which the electrode is guided along the seam at a rate of advance that has been determined to be correct for each kind of work.

In Fig. 7 are shown three examples of tank welding. In the small tank to the left, the longitudinal seam, as well as the bottom, is arc-welded. In the tank in the middle, the longitudinal seam is welded, and in the tank to the right, the longitudinal seam and the seam between the shell and the base have been welded. Fig. 5 shows an interesting example of a shell welded together from six separate pieces or segments. Fig. 6 shows the upper end of the inside of an electrically arc-welded seam in a tank. This view indicates how the metal from the electrode is forced clear through the seam, as indicated to the right, and also shows, to the left, the reinforcement at the end of the seam, where the seam is also welded from the inside. Fig. 8 indicates what can be done in the

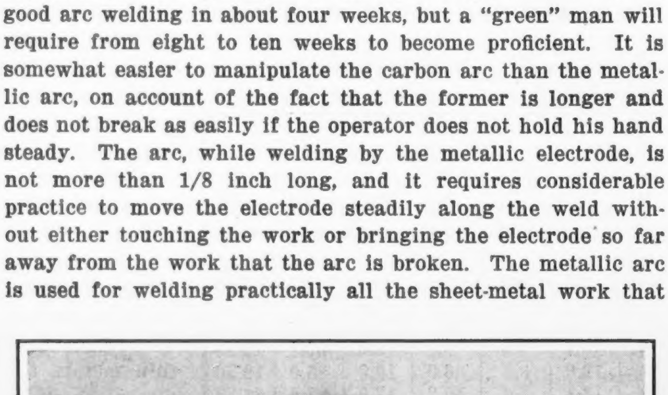

Fig. 8. Tank with Welded Seam, which has been ground Smooth

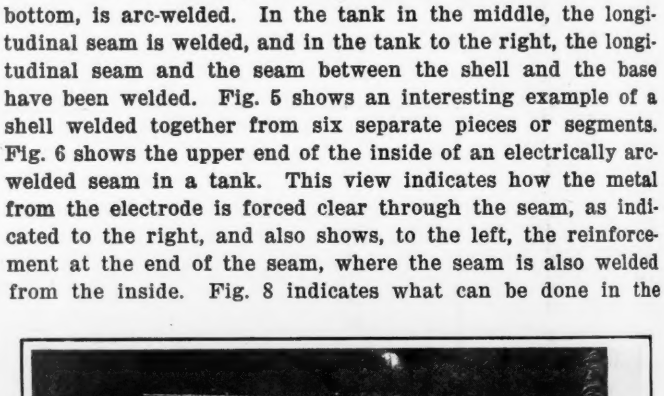

Fig. 9. View of Seam in Tank where Bottom is welded to Shell

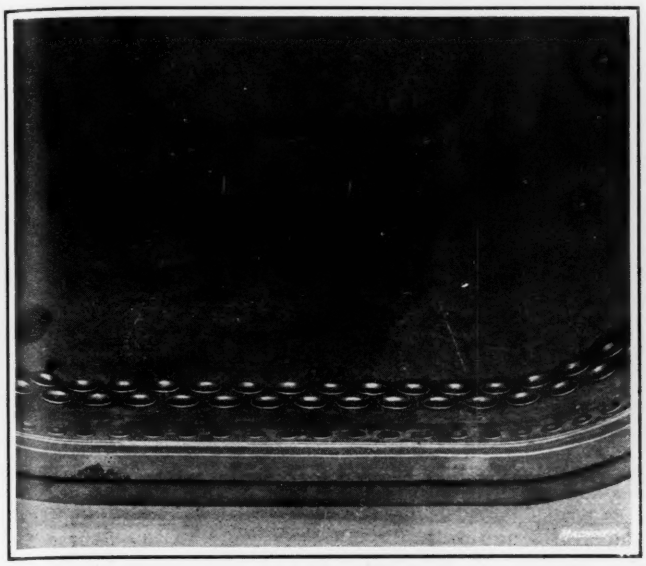

Fig. 10. Tubular Transformer Tank, showing Tubes expanded preparatory to Welding

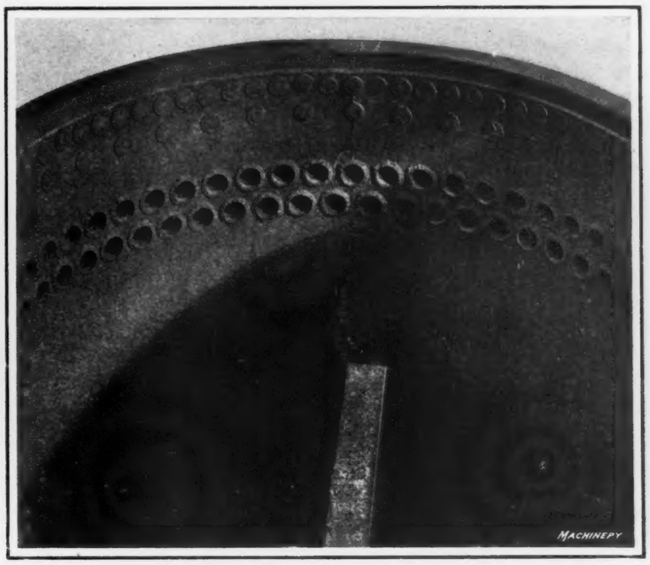

Fig. 11. Tubular Transformer Tank, showing Tubes after having been welded to Shell

way of finishing welded tanks so that the joint is practically imperceptible. The tank shown has welded seams at the corners and the surface of the weld has been ground off to present a smooth appearance, the weld being reinforced on the inside. If a tank made in this manner were painted, it would be impossible to find any joints whatever on the outside. In Fig. 9 is shown a view of the bottom of a large tank where a 3/4-inch base is welded to a 3/8-inch shell. The size of the tank is about 6 by 12 by 14 feet high. The illustration shows clearly the character of the weld.

Examples of the Application of Arc Welding

In addition to the welding of the longitudinal seams of the transformer tanks, the electric arc is used for a number of other welding operations in connection with the manufacture of transformers. The tubes are welded into oil-cooled transformers by the electric arc. The tubes are bent, inserted, expanded, and then welded. It has been found that this process is far superior to using oxy-acetylene for welding. In the past, out of 100 tubes welded by the oxy-acetylene process, about 10 per cent developed leaks. When welded with the arc-welding process, however, out of 100 tubes, only an average of one tube is found to leak. Fig. 10 shows the tubes in one of these tanks expanded preparatory to electric arc welding. Fig. 11 shows the tubes welded to the transformer shell, while Fig. 12 shows the completed tubular transformer tank in which the base and tubes are welded by the arc-welding process.

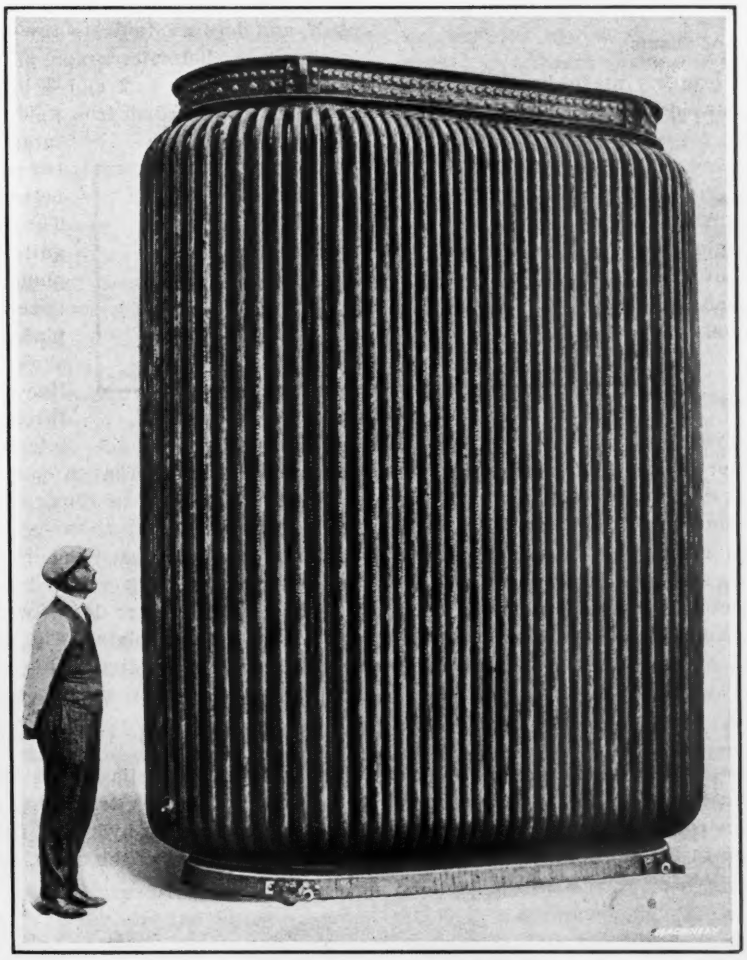

Fig. 12. Tubular Transformer Tank, Base, and Tubes welded by Electric Arc

Bolt heads and rivets are welded around the heads in order to insure oil-tightness. Fig. 13 shows a section of a riveted joint indicating the probability of leakage between the rivets and the plates, were it not for the welding at *A*, which provides for an oil-tight joint. Fig. 14 shows the appearance of the weld around the rivet heads. Welding around the rivet heads by means of the oxy-acetylene flame was tried, but was not found successful, because the heat from the flame when welding successive rivets caused the weld already made to crack.

Malleable-iron bosses are welded to sheet-steel tanks instead of being fastened by riveting. In this case, carbon electrodes with a soft metal feeding rod are used. The cast-iron heads, however, cannot be welded to the sheet-steel tanks, mainly because of the different expansions

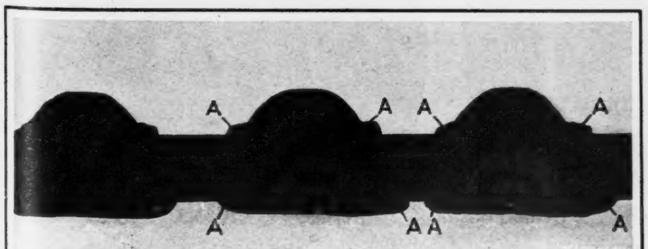

Fig. 13. Boiler Plate riveted together, showing Space between Rivets and Plate, and how Rivet is made Oil-tight by welding Head to Plate

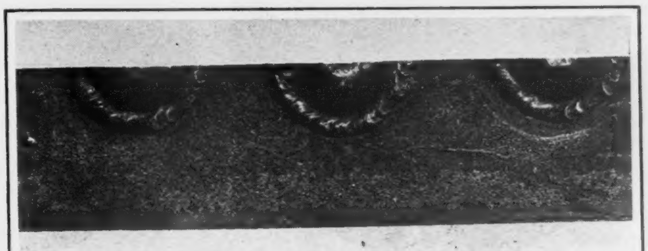

Fig. 14. Appearance of Welds when Rivet Heads have been welded to Plate by Electric Arc Welding

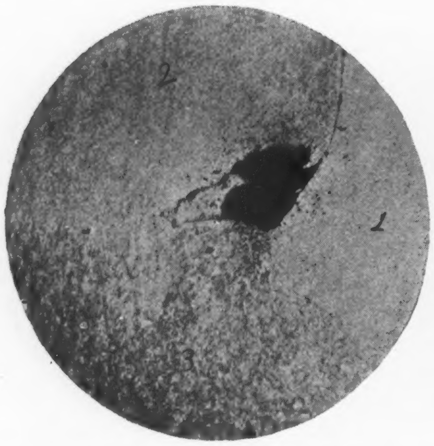

Fig. 15. Photomicrograph of Steel Tubing welded to Boiler Plate, taken at A in Fig. 18

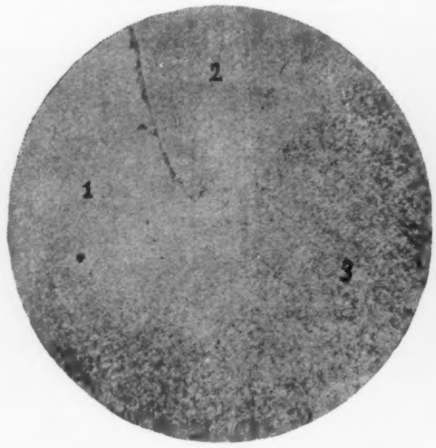

Fig. 16. Photomicrograph of Steel Tubing welded to Boiler Plate, taken at B in Fig. 18

Fig. 17. Photomicrograph of Rivet Head welded to Boiler Plate

in the two metals when welding; hence the cast-iron heads are riveted to the shells and the rivet heads welded as previously explained. Small corrugated tanks have the sheet-steel shell cast directly into the cast-iron flange.

The work is always the positive electrode, and the carbon or metallic electrode the negative terminal. The positive electrode may be clamped to the work anywhere.

Strength of Seams

The arc-welded butt-joint, if properly made, has been found to be quite as strong as a lap-welded single-riveted joint. A lap-welded joint will be found to be stronger than a single-riveted lap-joint, and as the joints required for the transformer tanks are sufficiently strong when single-riveted, it follows that either butt-welded or lap-welded seams made by the electric arc are amply strong.

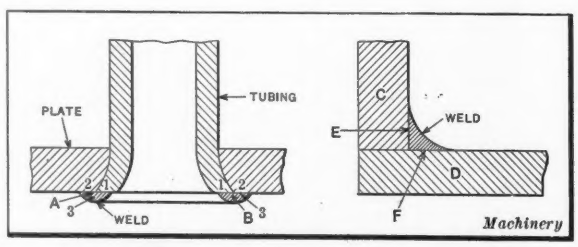

Fig. 18. Diagrammatical View of Welds illustrated by Photomicrographs

Data for Sheet-metal Welding

The accompanying table gives the thickness of metal, diameter of electrode used, speed per hour, current required, and cost of power and electrode for sheet-metal welding. This table is based on carefully made records, and represents actual experience in manufacturing work. Power is assumed to be available at 3 cents per kilowatt-hour, and the electrode metal is assumed to cost 5 cents per pound. The total cost per hour includes labor cost at the rate of 30 cents per hour, but, at the present time, with the high rate of wages, this is not sufficient.

Photomicrographs of Arc-welded Joints

Figs. 15 to 21, inclusive, show the appearance of arc-welded joints as seen under the microscope. At the left in Fig. 18 is shown a diagrammatical illustration of a tube welded to a flat plate. The photomicrograph in Fig. 15 is taken at *A*. The figures 1, 2 and 3 in Fig. 18 correspond to the figures 1, 2 and 3 in Fig. 15, the area indicated by 1 being the tubing; that indicated by 2 being the boiler plate; and that indicated by 3 being the weld, which is of Swedish iron. The black spot is a cavity at point *A* where the tube and the plate did not come together perfectly, there being a minute flaw or cavity at the edge of the plate. This cavity is not in the weld itself, and does not indicate any defect in the weld. In Fig. 16 is shown a photomicrograph of the same weld taken at *B*, where the figures 1, 2 and 3 indicate the tubing, the boiler plate, and the Swedish iron welding material, respectively, the same as in Fig. 15. The line between 1 and 2 shows the junction between the tubing and the plate. The homogeneity of the weld is quite apparent. Fig. 17 shows a photomicrograph of a weld between a rivet head and boiler plate, the welds themselves being shown in Figs. 13 and 14. The line of the weld runs vertically through the center of the photomicrograph between two areas that are slightly different in color. Fig. 19 shows the central part of the same weld as illustrated in Fig. 16, but at a higher magnification. Fig. 20 shows a photomicrograph of the joint at *E* between plate *C* and the welding material in the case of two boiler plates being welded together, as shown to the right in Fig. 18. The figure 1 is Swedish iron welding material, and 2 is the boiler plate. Fig. 21 illustrates the joint at *F* and is made with a slightly higher magnification. Here 1 is again the Swedish iron welding material, and 2 the boiler plate.

Cutting Metal by the Arc or Oxy-hydrogen Flame

The ends of the shells for the transformer tanks must often be trimmed, and this trimming or cutting of the metal is performed by the oxy-hydrogen flame rather than by the electric arc, on account of the clean, smooth cut that the hydrogen

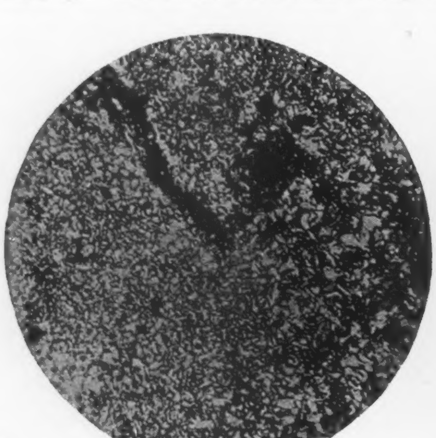

Fig. 19. Enlarged View, showing Center of Weld in Fig. 16

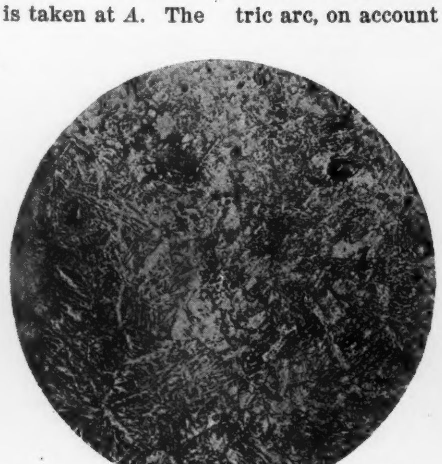

Fig. 20. Photomicrograph showing Joint between Welding Metal and Boiler Plate

Fig. 21. Another Photomicrograph showing Joint between Welding Metal and Plate

flame will produce. While the arc could be used for this purpose, it has not been found advantageous, on account of the length of time that would be required in the effort to obtain a smooth cut, and, furthermore, the result would not be as satisfactory as that obtained by the hydrogen flame; hence, in the manufacture of transformer tanks, it has been found that there is a distinct field for the electric arc and for the gas flame. The electric arc is used for all welding operations, while the gas flame is used for the trimming or cutting operations. In welding, the electric-arc method has also one other great advantage over the oxy-acetylene method, in that, when using the metallic electrode, the position of the seam or weld is of no importance. It may be overhead, vertical or horizontal. The weld can be properly made in every case. The metal from the feeding rod is actually carried over with considerable force by the arc, and is driven against the welded surfaces, even when the electrode is held underneath the seam to be welded. Work of this kind, of course, cannot be accomplished by the oxy-acetylene flame, as in that case the molten metal from the feeding rod drops, by gravity, into the weld, and hence the weld must always be in a horizontal or nearly horizontal position.

The author wishes to express his indebtedness to R. E. Wagner, of the General Electric Co., for assistance rendered in obtaining the information on which this article is based. Mr. Wagner is responsible for the development of the arc-welding process as applied to the welding of large transformer tanks at the Pittsfield Works.

* * *

GRINDING FACTS AND SUGGESTIONS

Truing of grinding wheels is always accomplished by the use of diamonds, never with so-called "wheel dressers." The dressing is done with wheel dressers. Truing is not a sharpening operation, but just what its name implies. Dressing can never true a wheel, but it can and does break up the surface of the wheel and cause it to cut more roughly and more rapidly. Only a part of its cutting points are true or perfectly concentric, and not all are the same radius. Therefore, the wheel is not true, although it is a fact that the wheel dresser can make a wheel approximately concentric by its use. One should never attempt to grind precision work with a wheel that is dressed, although some rough grinding is best done with wheels that are dressed. This is especially true in the case of grinding from the rough stock, or forgings, like crankshafts of automobiles.

There is a popular notion that water and lubricant of various kinds is used to keep work cool. It is not at all necessary that the work should be kept cool when grinding, but it is necessary that it be kept at a nearly uniform temperature during the passage of the wheel over the entire length of the work being ground, although no particular temperature need be maintained. It may be cold or it may be very hot. The work does not have to be of the same temperature for different passes over the same piece of work; it is only necessary that with each pass the temperature shall remain nearly constant from one end to the other, so that the work may remain straight. Increasing the temperature from the end to the center will cause the work to spring and the wheel to cut on one side of the work deeper than on the other side; then when the work returns it will cut on the opposite side; and at the next pass it will cut at right angles, and so on, as long as grinding continues with insufficient lubricant or with a wheel too hard for the work, or both. Any liquid can be used, but clear water will rust both the machine and the work. Carbonate of soda added in sufficient quantity will prevent rusting, and many use this mixture. A better mixture is one containing oil. There are compounds made for grinding machines that are rich in oil, and these are no doubt better than water and soda. The life of the grinding wheel and the production are both increased by increasing the lubricating feature of the liquid.

There is a popular belief that oil will prevent grinding wheels from cutting. This belief is so strongly fixed in the minds of some that when they discover there is oil in the lubricant furnished with their machine they report that the compound causes the wheel to glaze and prevents cutting. Such persons should know that the best cutting wheels are used with compound, and that many thousand machines are producing the best quality and a phenomenal amount of work by the use of compound, and that the wheel maintains its shape and sharp cut as by no other known method. The lubricant should never be allowed to become thick. Keep it mixed as directed by the maker. Never assume to know better than the maker about mixing the lubricant. If the lubricant is too thick, the work will not grind true. If it is too thin, the machine and work will rust.

Wheels give service according to the conditions surrounding their use. A series of experiments was made with a view to using a wheel under ideal conditions. These experiments showed that when the conditions were ideal the wheel would give a service of 20 cubic inches of steel removed for 1 cubic inch of wear from the wheel. With careless or ignorant use, not more than 2 cubic inches of steel may be removed to 1 cubic inch of wheel wear. In everyday practice in some places the wheel removes 3 cubic inches of steel to 1 cubic inch of wheel wear. In the grinding of very large chilled iron rolls, 16 cubic inches of chilled iron to 1 cubic inch of wheel wear is obtained. In some places where steel work is ground, 10 cubic inches of steel is removed to 1 cubic inch of wheel wear.

The causes of wheel waste are: wheel not in balance; wheel too soft for the work; work speed too fast for the wheel grade; insufficient steadyrest support; wheel-spindle too loose in the bearing; very careless hand feeding, *i. e.*, feeding too much at one time and too little at another; any vibration of the machine or work. To increase the wheel service, use the automatic cross-feed at all times. Sharp corners of wheels may be preserved and yet the work may be produced rapidly by using the automatic cross-feed. When the same amount of work is done with hand feed the corners of the same wheel will probably be destroyed.

Support the work rigidly with plenty of solid non-yielding steadyrests (no spring).

See that the wheel is well balanced.

See that there are no heavy lacings or knots in the belt that drives the work and the wheel.

Look after all things that cause vibration.—*Grits and Grinds*

* * *

WEAR IN LARGE GUNS

In an article in *Arms and Explosives*, the subject of wear in large guns, which has a most important influence on the cost of the war, is dealt with. The increased cost due to wear depends on two factors: first, the expense of making repairs, and, second, the increase in the amount of ammunition expended to attain a definite object on account of the inaccuracy of firing due to the wear of the gun. The author, Major Tulloch, of the British Army, says, "If a few thousandths of an inch of steel at the beginning of the rifling of guns could be prevented from wearing away in so short a time as at present, the reduction in the cost of the war, so far as guns, ammunition, transport, etc., are concerned, would be almost incalculable." The damage to the bore near the breech is known as "corrosion," while that near the muzzle is termed by the author "erosion," as it is due purely to mechanical causes. Corrosion in big guns is caused by high temperatures, chemical and physical qualities of the powder, weight of charge and rapidity of firing, escape of gas past projectile, and composition and physical properties of steel used for the inner tubes of the gun. It is pointed out that the methods of making the inner tubes and their heat-treatment are still capable of much improvement. As an indication of the erosion that takes place when a projectile is fired, it is mentioned that, by electrolytic methods, in one case over fifteen pounds of copper was removed from the bore of an eight-inch gun that had fired slightly over one hundred rounds, this copper having been torn from the copper bands on the projectiles.

* * *

Because of gasoline restrictions, bicycles are again becoming popular in England, replacing automobiles and motorcycles.

SPUR GEARING PRODUCED BY THE ROTARY CUTTER PROCESS[1]

The present highly developed state of the gear-cutting art is not an over-night growth. What we know as an accurate gear today is not the result of the automobile, the trolley car, or any other particular demand. It is the product of a slow, steady growth until practically every class of machinery requires cut gears, whereas years ago the cast-tooth gear was the rule and the cut-tooth gear the exception. But in those days, when lathes, shapers and planers had cast-tooth gears throughout, the gears were made with greater nicety than the rough cast gears seen today in so-called "rough mill work." Even the change-gears on screw-cutting lathes had cast teeth, and they ran much better than some of the rough-cut work obtained nowadays from concerns that know very little about cutting an accurate gear and employ incompetent workmen. It does not matter by what process a gear is cut; if the arbor runs out, or the gear is otherwise not properly mounted, bad work is the result and the gear will be noisy.

In 1867, exactly fifty years ago, the writer entered the machine and gear industry, by being bound to serve six and one-half years as an apprentice in the building of gear-cutting engines, as they were called at that time. His master, Ezra Gould, was a master of the now lost art of working with a hammer and chisel, shoulder and hand tools, also with hand chasers for cutting threads. Few of the lathes had lead-screws in those days. Mr. Gould designed a gear-cutting engine, about 1848, that used a disk cutter and had the dividing worm-wheel made in two parts, so that it could be corrected. The machine was fed and indexed by hand. In 1852, at the Crystal Palace Fair, New York City, he received a silver medal for this machine.

The writer's first experience in cutting gears was on a machine of this type, and at that time there were very few gear-cutting engines in his state and none at all west of Pennsylvania, so far as he knows, because the demand for cut gears was very small. Most gears coarser than ten or twelve diametral pitch were generally made with cast teeth, and many wooden, iron and brass patterns were cut. Coarse-pitch gears with cut teeth were only made on special order for what was considered very nice, accurate work.

The cutters were not the form cutters of today, which can be purchased right out of stock and sharpened without trouble. They were all homemade, of the fine-tooth type, nearly like a circular file, and had practically no chip room. A cutter, say, of six diametral pitch and three inches in diameter would nowadays have about twelve cutting teeth; in those days it had about forty-eight teeth, on the supposition that the more teeth it had the faster it would cut. However, when the cutter became so dull that it would not cut but would practically push the metal out of the back of the wheel, nearly ruining it, the operator would stop, anneal the cutter, remill the cutting teeth, and harden the cutter again. Sometimes he was fortunate enough to maintain the previous tooth form, but generally each cutting produced a new form. In fact, to show how far we have advanced from those early days, where we nowadays have eight cutters in each pitch and special cutters for more refined work, in those days we had only two cutters. One was marked with the letter L and the other with the letter S. The L stood for large gears and the S for small gears. When the gears were medium sized, the operator could decide which cutter to take. The writer remembers, when a boy, turning up about a dozen of these cutters in the lathe and milling the teeth on them for a customer who had purchased a gear-cutting machine, yet when it was time to mark these cutters, just before hardening them, he could not tell which cutters should have the L and which the S. The gages used for obtaining the tooth form were made from actual gears that showed up especially good in practice. Some of these gears ran smoother and with less noise than gears cut with cutters made from templets laid out with the theoretical involute curve, because such early gears had teeth with practically modified tooth form, whereas the gear-tooth designer or draftsman usually laid out a gear tooth without any modification whatever.

You can imagine the writer's interest in the cutters that were being introduced by Brown & Sharpe, which could be sharpened without changing their form. These cutters impressed him as being good, but his efforts to introduce them in the shop were vigorously opposed by his superiors. A demonstration, however, caused the new cutters to be adopted. Then new troubles arose. The cutters had more chip room and fewer teeth, and therefore took a heavier chip. This gave the operator quite a jerk when he was operating the hand-lever feed with which many of the machines were then provided. The cutting edges were so far apart that each time the cutter touched the work it gave the operator a regular hammer blow. It was hard on the cutters also. It was only a few steps from this improvement to making the machine entirely automatic, which was a little before 1883.

After the first machine proved a success, the firm soon had several machines running night and day because the demand for cut gears was continually growing. Electric trolley cars were becoming commercially successful, and cut gears were just as important as the motors. Each car had a four-gear reduction: a rawhide pinion on the motor driving a large gear and a steel pinion on the intermediate shaft driving a large gear on the axle. The wear and tear were great, for the gears and motor were not encased, so that dirt and grit destroyed the gear teeth rapidly. The cost of the gears, therefore, became the important factor. Even though one man could attend to from five to eight automatic machines, the production was not enough to reduce the cost to the low point demanded.

It seemed to the writer that one disk cutter per machine was not enough, so, about 1892, he made a triplex, automatic gear-cutting machine, having three separate cutter-spindles. These cutters were arranged in tandem, one behind the other, so that stock cutters could be used. Three gear blanks were mounted on the work-arbor, with spacing collars between. Thus the cutter carriage traveled only the width of the face of one gear to cut the three gears. This was very fast, but was not the maximum production desired, so the radial duplex cutter, using two or more cutters on the same spindle at one time, and thus cutting more than one tooth at one time, was devised. By putting three of these gang cutters on each of the three spindles of the triplex gear-cutting machine, it was possible to finish nine teeth at one passage of the cutter carriage. The machine was good in every respect, but was too light for the heavy duty demanded of it.

The cast-iron motor gears in general use in those days, which had sixty-seven teeth and were three diametral pitch, were falling behind the pinions; so it was decided to rough out all the teeth of the gear at once. Therefore a machine was made that had a cutter for each tooth, or sixty-seven cutters, all acting at once. The cutters were made of 5/8-inch square steel and were ground to 14 1/2 degrees. The gear blank was moved up and down by a powerful crank motion, while the cutters were fed toward the center, simultaneously, by means of a circular rack. The tools released themselves on the return stroke. The machine worked well and would stock out the sixty-seven teeth in about sixteen to eighteen minutes. The gear was then placed in the triplex gear-cutting machine and finished, using a gang of three cutters and feeding about six inches per minute.

It might be of interest also to mention that the writer designed and built at that time a vertical boring machine to turn the diameter, face off both sides of the rim, turn the diameter of both the hubs, and bore, rough-ream and finish-ream these motor gears in one operation or setting. The boring-bars were driven independently, thus maintaining the best cutting speeds and permitting nearly all operations to take place simultaneously. The complete time was about eighteen minutes per gear. In fact, the work was going very nicely when the order came to make all the gears of steel. New troubles arose, because the entire equipment was altogether too light to make steel gears on a manufacturing basis. This brings us to the present-day practice, with high-speed steel cutters, high-duty machines and high wages.

[1] Paper read before the American Gear Manufacturers' Association at Chicago, September, 1917, by Henry E. Eberhardt, of the Newark Gear Cutting Machine Co., Newark, N. J.

Through all these fifty years the disk cutter has held its own. It has a range from as fine as sixty-four diametral pitch up to six inches circular pitch. The work can be forced or it can be done carefully to produce accurate work; the disk cutter can also be depended upon where low cost and a fair degree of accuracy are required. As to the form of tooth now used—the modified involute—it must be borne in mind that it was easy to change the previous forms, after practice had indicated what was wanted. In other words, where the form needed modification, the disk cutter readily lent itself to such changes, because it could be seen in advance just what form would be produced. In December, 1908, the American Society of Mechanical Engineers appointed a committee to investigate and report upon the subject of interchangeable involute gearing and to make recommendations. A report, made by a majority of the members, in 1913, touched upon some of the technical points relative to the addendum, also to the pressure angles in use. It also stated that the gears cut by the Brown & Sharpe Mfg. Co. with disk cutters ran more quietly than those cut by any other method. Still each method was evolved by necessity and has its individual field. No one method has driven the others out of the field as yet, because no one method covers the entire range of requirements.

* * *

WORKMEN'S COMPENSATION IN MUNITION PLANTS

BY CHESLA C. SHERLOCK [1]

The effect of the war upon the workmen's compensation acts in this country cannot be ascertained at this time. We may, however, surmise the general attitude the courts and commissions will take where injuries are received through conditions due to the war by examining the decisions handed down by the English courts. One decision that is particularly interesting is the case where an engineer was engaged in his usual occupation in an English town on the east coast of that country. German warships appeared in the harbor and commenced to shell the town, and the claimant sought refuge under a truck where he remained for some time. It then occurred to him that the injector should be opened or the steam pipes on the engine would be burned, so he went to perform this service and while returning to his place of refuge was struck by a fragment of a shell which smashed his left arm. Lord Cozens-Hardy, perhaps the foremost compensation authority in the British Isles, handed down the decision of the court. His Lordship held that no compensation was allowable for the reason that the claimant was subjected to no greater risk than others in the vicinity; that the hazard was common to all and for that reason the injury did not arise out of and in the course of the employment.

There are other cases of general interest that have been decided since the war broke out, but our chief attention is directed to those accidents that have occurred in munition works. The English courts put a great deal of stress upon the subject of notice. If the employer is not promptly notified of an injury by the injured employe or someone on his behalf, it is customary to absolve the employer from all liability under the law for the payment of compensation. That rule is not usually followed in this country. In one English case a young woman received an injury to her left eye while working in a munition plant. The evidence was such as to justify a finding that she received her injury "by accident arising out of and in the course of" her employment. Upon appeal, the court set aside the award upon a technical question of notice.

In another case a workman was injured prior to the declaration of war and received compensation to the amount of one-half his weekly wages. When war broke out his employers posted a notice that they would pay their employes, who volunteered or were sent to the front, full wages after deducting what they received from the government. The workman continued to draw his half-pay until the following year when he recovered his normal physical strength and commenced to draw full pay. A short time later he enlisted in the army and being killed his widow brought action for compensation. The court found that the workman came within the terms of the offer posted by his employers and that as he was drawing full pay at the time he enlisted, he was entitled to receive the benefits of the compensation offered by the employers according to the restrictions before mentioned. The question has frequently arisen in England as to whether or not compensation should be cut off, where paid for physical incapacity, when the so-called injured man has been accepted in the army. Justice would seem to indicate that such a rule should obtain and indeed the courts have so decided.

Where compensation is based upon the difference between the wages that the workman earned at the time of injury and those that he is able to earn after injury in the same employment, the question has come up that if he enlists in the army he is not earning wages in the sense intended by the act and, in fact, is not employed in an industrial employment at all. The point was also brought out that the employer has no means of ascertaining the amount of compensation due and for that reason no compensation is payable. This case came up and the arbitrator held that the employer was relieved from liability, but the court on appeal reversed the decision, stating that the estimate could be made upon the soldier's present physical condition and what he was able to earn in such condition if employed in an industrial occupation.

The tendency in compensation practice in England seems to be to preserve the compensation rights of workmen in every case where it is possible. In fact, the integrity of the compensation service demands that it should be preserved as nearly as consistent with the ends of justice against the inroads of war. If compensation is to survive these times of trial and suffering, much depends upon the attitude that the employers of this country take toward it. The mere fact that a man is called to the colors should not encourage employers to take advantage of his absence and seek to relieve themselves of the payment of the compensation due to his dependents or representatives. The English courts have, as a rule, blazed a wide, liberal path for our courts and commissions to follow, and it is hoped that American employers will be as open-minded as English employers.

[1] Address: Box 253, Des Moines, Iowa

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AN AFTER-THE-WAR MACHINERY PROBLEM

The demand for scrap metal for use in the production of munitions has brought out of various branches of industry considerable machinery that up to the beginning of the war had been used, but has now become obsolete. The high prices of scrap metal of all kinds have been a strong inducement to owners to sell everything that can be spared and then arrange to re-equip their works as soon as possible. There are two main causes of this clearing-out process: most of the industries that were diverted to war purposes found a proportion of the machinery unsuitable; if it were old or badly worn, it could not profitably be installed again, and so was put on the scrap heap. Capital has been gradually withdrawn from the industries seriously affected by war conditions, and new industries have been fostered. In Great Britain, vehicle and furniture factories, builders' plants, etc., have been almost idle so long that some of the unused machinery is worth only the weight of the metal. Then, too, considerable metal has been obtained from farms where the motor tractor has thrown into disuse old types of plows and other implements.

Not the least of the difficulties of industrial reconstruction on a normal basis after the war will be the problem of unsuitable machinery, no inconsiderable proportion of which will probably find its way to dealers in scrap metals. Manufacturers of machinery will require time to construct new equipments, in whole or in part, and therefore to owners of plants now devoted exclusively to war work the question of readiness to take up old or new lines of production immediately on the cessation of hostilities is an urgent one. At best, the adaptation of present plants to old or new uses will, it is thought, be a slow process, and for some time alert manufacturing firms have been thinking and acting ahead.—*United States Commerce Reports*

PIN MEASUREMENT OF SPUR GEARS

PRINCIPLES GOVERNING PIN MEASUREMENT AND DERIVATION OF FORMULAS USED

BY REGINALD TRAUTSCHOLD [1]

SPUR gearing enters into the operation of many intricate and accurate mechanisms, and, quite obviously, the efficiency of such transmission and its satisfactory operation must largely depend upon the accuracy with which the gears and their teeth are finished. Yet when it comes to checking up spur gears, the unusual condition is encountered of having nothing definite from which to measure. Gears are proportioned from what may be termed an imaginary line or circumference—the pitch circle. The teeth may have long or short addenda, the pressure angle may vary, etc. Of course, the pressure angle is now pretty well standardized, but this does not materially affect the problem, for measuring the diameter of gears from the top of the teeth or from the base of the tooth spaces cannot establish their accuracy on the pitch circumference. The latter is governed by one dimension—the pitch diameter—which must not vary and which must be accurately established for satisfactory operation and exact ratios.

In order to ascertain accurately the measurement of this elusive dimension, pin measurement of spur gears has been developed. This system consists simply in measuring the distance between suitably proportioned pairs of pins that bear on the profile pitch lines of pairs of adjacent teeth. In gears with an even number of teeth, the pins are inserted between pairs of diametrically opposite tooth spaces; in gears with an odd number of teeth in which a tooth is diametrically opposite a tooth space, the second pin has to be placed in a tooth space most nearly opposite the first pin. The measurement in this instance is not one of diameter, but of a chord as nearly the length of what would be the corresponding diameter of a gear with an even number of teeth as can be secured.

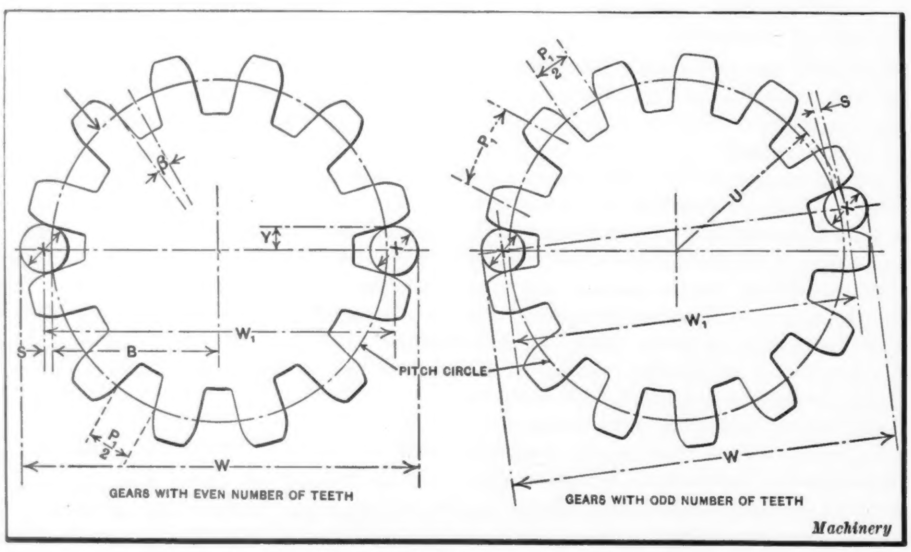

Fig. 1. Methods of taking Measurements of Spur Gears

The method of making pin measurements of gears with even and odd numbers of teeth is shown in Fig. 1, from which it is evident that the distance between pin centers or, what is customarily taken, the distance over the pins must accurately measure the pitch diameter of the gears—directly in one case and in the other by a chord that bears a definite relationship to the diameter of the gear. The diameter of the pin employed is an important factor and is naturally controlled by the width of the tooth spaces. The logical size of pin would appear to be that which, when resting in the tooth space, will bear on the pitch points of the respective tooth profiles in such a way that radii of the pin to such points will be normal to the tooth profiles.

Such a proportioned pin is shown in Fig. 2, the diameter of which can be readily calculated for use with teeth of any specific pressure angle. The angle subtended on the pitch circle by the tooth space is easily calculated, for one-half this angle is equal to 360 divided by four times the number of teeth in the gear, or $\beta = \frac{360}{4N} = \frac{90}{N}$. The chordal width of the tooth space is likewise easily calculated and the pressure angle is known. Then the distance H_1 between the chordal plane of the tooth space and the point where planes tangent to the tooth profiles on the pitch circle intersect is equal to half the chordal width of the tooth space multiplied by the cotangent of the pressure angle. This establishes the location of point Z, Fig. 2. The distance H_2 between the point Z and the center of the pin is equal to the distance between this point of intersection and the chordal plane of the tooth space multiplied by the square of the secant of the pressure angle. The distance between the center of the gear and the chordal plane of the tooth space is then equal to the pitch radius of the gear multiplied by the cosine of the angle subtended by one-half a tooth space. With such dimensions established, the distance between the center of the pin and the center of the gear is readily obtained, and also the diameter of the pin. For convenience, this pin diameter may be designated as the "standard"; that is, it is the diameter of a pin that will be tangent to adjacent tooth profiles at points on the pitch circle.

Finding Size of Pin

For a given pitch, the standard diameter of a pin is obviously dependent upon the number of teeth in the gear, and it must increase with the number of teeth. In other words, as the curvature of the pitch circle is decreased the chordal width of the tooth spaces increases, while the width measured on the pitch circle remains constant. For instance, the standard diameter of a pin for a gear of five diametral pitch having six teeth—about the smallest number of teeth that will be encountered in practice—will be 0.320802 inch, while for a similar gear with fifty teeth the diameter of the standard pin will be 0.324434 inch, an increase in diameter of 0.00363 inch.

Notation for Formulas

Pitch diameter	D
Pitch radius	R
Number of teeth	N
Diametral pitch	P
Circular pitch	P_1
Pressure angle	a
Half angle subtended by tooth space	β
Half chordal width of tooth space	Y
Chordal ordinate	B
Pin center amplitude	S
Offset of pin center (gears with an odd number of teeth)	O
Pin center gear ordinate (gears with an odd number of teeth)	H
Diameter of pin	X
Pin center spacing	W_1
Pin center radius	U
Width over pins	W
Backlash	L
Half angle subtended by tooth space plus backlash	β_1
Half chordal width of tooth space with backlash	Y_1
Pin center amplitude with backlash	S_1

Formulas Used in Pin Measurements

$$D = \frac{N}{P} \quad (1) \qquad R = \frac{D}{2} \quad (2) \qquad P_1 = \frac{3.1416}{P} \quad (3)$$

[1]Address: 39 Charles St., New York City.

$$\beta=\frac{90}{N}\quad(4)\qquad \beta_1=\frac{45(P_1+L)}{1.5708D}\quad(5)\qquad Y=R\sin\beta\quad(6)$$

$$Y_1=R\sin\beta_1\quad(7)\qquad B=R\cos\beta\quad(8)\qquad S=\sqrt{0.25X^2-Y^2}\quad(9)$$

$$S_1=\sqrt{0.25X^2-Y_1^2}\quad(10)\qquad U=B+S\quad(11)$$

$$O=U\sin 2\beta\quad(12)\qquad H=O\cot 2\beta\quad(13)$$

$$W_1=2U\quad\text{Gears with even number of teeth}\quad(14)$$

$$W_1=\sqrt{O^2+(H+U)^2}\quad\text{Gears with odd number of teeth}\quad(15)$$

$$W=W_1+X\quad(16)\qquad X=2R\sin\beta\sec\alpha\quad(17)$$

$$X>2Y\quad\text{but not}>2Y\sec\alpha\quad(18)$$

Discussion of Formulas

A different size of pin for measuring each gear that differs in the number of teeth or in pitch will result in such a multiplicity of gages, however, as to detract seriously from the method of measurement, particularly if the number of pins is to be also increased by the number of different pressure angles employed. Fortunately, this can be avoided without sacrifice in accuracy. In the first place, the pressure angle factor does not affect the diameter of the pin as much as may be imagined. For instance, take two 6-tooth gears of 3 diametral pitch, one having a pressure angle of 14.5 degrees and the other one of 20 degrees, the hypothesis for Example 1. The standard diameter of the pin will vary about 0.015 inch for the two gears.

Example 1—Required the pin diameter X for 6-tooth gears, 3 diametral pitch, with 14.5- and 20-degree pressure angles.

$$D=\frac{6}{3}=2\text{ inches}\quad(1)\qquad R=1\text{ inch}\quad(2)$$

$$\beta=\frac{90}{6}=15\text{ degrees}\quad(4)$$

For gears having a pressure angle of 14.5 degrees:

$$X=2\times 0.25882\times 1.0329=0.53466\text{ inch}\quad(17)$$

For gears having a pressure angle of 20 degrees:

$$X=2\times 0.25882\times 1.0642=0.55006\text{ inch}\quad(17)$$

Fig. 4 illustrates how a pin of slightly smaller diameter than that which has been referred to as standard can be employed for the accurate measurement of gears, thus materially reducing the number of pin diameters required. The broken-line circle depicts a pin of standard diameter and the full-line circle a slightly smaller pin. Both circles are, however, of greater diameter than the chordal width of the tooth space, and the contacts of both circles are at the pitch point of the respective tooth profiles. In the case of the pin of standard diameter, radii to the points of contact are normal to the tooth profiles, while in the case of the smaller circle such radii are not normal to the tooth profiles. Below, or within, the pitch circle, the curvature of the tooth profiles and the curvature of the pins are opposed and the contact between the pins and the teeth must take place at the extremities of the common line that depicts the chordal width of the tooth space and joins the pitch points on the adjacent tooth profiles. The measurement of the pitch diameter, therefore, may be as accurately obtained with the smaller pin as with the one of standard diameter. The only requirement is that the diameter of the pin is greater than the chordal width of the tooth space.

Though the diameter of the pin used may be slightly less than that of the standard diameter for the particular gear, it must not be greater, for, immediately above the pitch circle, the curvatures of the pin and of the tooth profiles are in the same direction and that of the pin is the greater. The effect of this, with a pin of greater diameter than the particular standard, would be to cause the pin to rest on the tooth profiles at a point above, or without, the pitch circle. The diameter of the pin must, therefore, be between that of the standard for the particular gear and the chordal width of the tooth space. This latitude permits the same size pin to be employed for measuring a number of gears of the same pitch, but differing considerably in the number of teeth. Within the range of the smallest and the largest gears of the same pitch cut in any particular shop, several diameters of pins may be required, but in all cases the diameter of the pin must fall within the aforesaid limits.

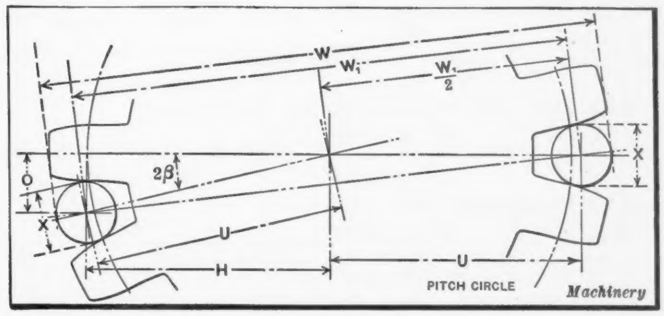

Fig. 3. Pin Measurement of Spur Gears wth Odd Number of Teeth

The amplitude of the pin center, or the distance it lies above the chordal plane of the tooth space, is equal to the square root of the square of half the pin diameter minus the square of half the chordal width of the tooth space. This relationship exists for any pin of suitable diameter.

Allowance for Backlash

The foregoing deductions are based on the assumption that the width of the teeth and the tooth spaces are equal. Cases frequently arise, however, in which a certain backlash is permissible and sometimes it is essential. The effect of this backlash is equivalent to increasing the arc of the pitch circle confined within the tooth space; that is, one-quarter the backlash may be considered as being removed from the profiles of each of the bounding teeth, as shown in Fig. 5. The effect of this is to cause the pin to sink farther down between the teeth, but the contact points between the pin and the respective tooth profiles remain on the pitch circle, for the diameter of the pin must remain greater than the increased chordal width of the tooth space.

The angle subtended by a tooth space permitting backlash is equal to the angle of an arc on the pitch circle that is equal to one-half the circular pitch plus one-half the total amount of backlash. The chordal width of the tooth space is then equal to twice the product of the pitch radius by the sine of the increased subtended angle, and the radius amplitude of the pin center is found, as before, from the diameter of the pin and one-half the chordal width of the tooth space.

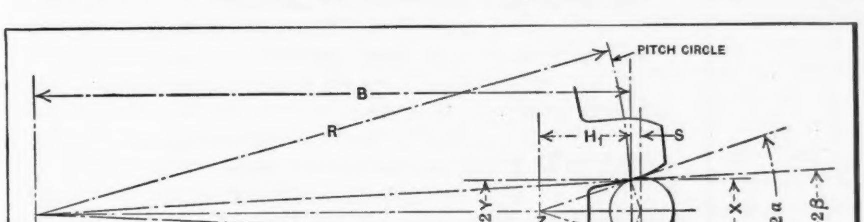

Fig. 2. Pin Measurement of Spur Gears

Example 2—Required pin measurements for 30- and 33-tooth gears, 3 diametral pitch, 20-degree pressure angle; first, without backlash; second, with 0.001 inch backlash, and third, with 0.005 inch backlash.

For a 30-tooth gear:

$$D=\frac{30}{3}=10\text{ inches}\quad(1)$$

For a 33-tooth gear:

$$D=\frac{33}{3}=11\text{ inches}\quad(1)$$

$$P_1=\frac{3.1416}{3}=1.0472\text{ inch}\quad(3)$$

With no backlash, for the 30-tooth gear:

$$\beta=\frac{90}{30}=3\text{ degrees}\quad(4)$$

and for the 33-tooth gear:

$$\beta = \frac{90}{33} = 2.7273 \text{ degrees} \qquad (4)$$

With 0.001 inch backlash, for the 30-tooth gear:

$$\beta_1 = \frac{45 \times 1.0482}{1.5708 \times 10} = 3.0029 \text{ degrees} \qquad (5)$$

and for the 33-tooth gear:

$$\beta_1 = \frac{45 \times 1.0482}{1.5708 \times 11} = 2.7299 \text{ degrees} \qquad (5)$$

With 0.005 inch backlash, for the 30-tooth gear:

$$\beta_1 = \frac{45 \times 1.0522}{1.5708 \times 10} = 3.0143 \text{ degrees} \qquad (5)$$

and for the 33-tooth gear:

$$\beta_1 = \frac{45 \times 1.0522}{1.5708 \times 11} = 2.7403 \text{ degrees} \qquad (5)$$

With no backlash, for the 30-tooth gear:

$$Y = 5.0 \times 0.05234 = 0.26170 \text{ inch} \qquad (6)$$

and for the 33-tooth gear:

$$Y = 5.5 \times 0.04758 = 0.26169 \text{ inch} \qquad (6)$$

With 0.001 inch backlash, for the 30-tooth gear:

$$Y_1 = 5.0 \times 0.05239 = 0.26195 \text{ inch} \qquad (7)$$

and for the 33-tooth gear:

$$Y_1 = 5.5 \times 0.04763 = 0.26197 \text{ inch} \qquad (7)$$

With 0.005 inch backlash, for the 30-tooth gear:

$$Y_1 = 5.0 \times 0.05259 = 0.26295 \text{ inch} \qquad (7)$$

and for the 33-tooth gear:

$$Y_1 = 5.5 \times 0.04781 = 0.26296 \text{ inch} \qquad (7)$$

With no backlash, for the 30-tooth gear:

$$B = 5.0 \times 0.99863 = 4.99315 \text{ inches} \qquad (8)$$

and for the 33-tooth gear:

$$B = 5.5 \times 0.99887 = 5.49379 \text{ inches} \qquad (8)$$

With 0.001 inch backlash, for the 30-tooth gear:

$$B = 5.0 \times 0.99862 = 4.99310 \text{ inches} \qquad (8)$$

and for the 33-tooth gear:

$$B = 5.5 \times 0.99886 = 5.49373 \text{ inches} \qquad (8)$$

With 0.005 inch backlash, for the 30-tooth gear:

$$B = 5.0 \times 0.99861 = 4.99305 \text{ inches} \qquad (8)$$

and for the 33-tooth gear:

$$B = 5.5 \times 0.99886 = 5.49373 \text{ inches} \qquad (8)$$

Maximum $2Y = 0.5259$ inch; therefore, from Formula (18), make $X = 0.55$ inch.

With no backlash, for the 30-tooth gear:

$$S = \sqrt{0.075625 - 0.068487} = 0.08449 \text{ inch} \qquad (9)$$

and for the 33-tooth gear:

$$S = \sqrt{0.075625 - 0.068482} = 0.08452 \text{ inch} \qquad (9)$$

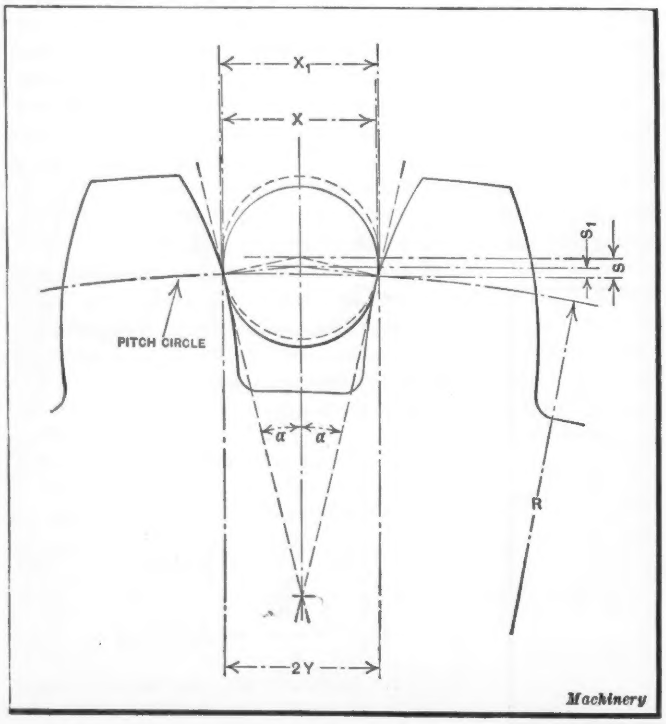

Fig. 4. Measurement with Pins proportioned for Smaller Gear

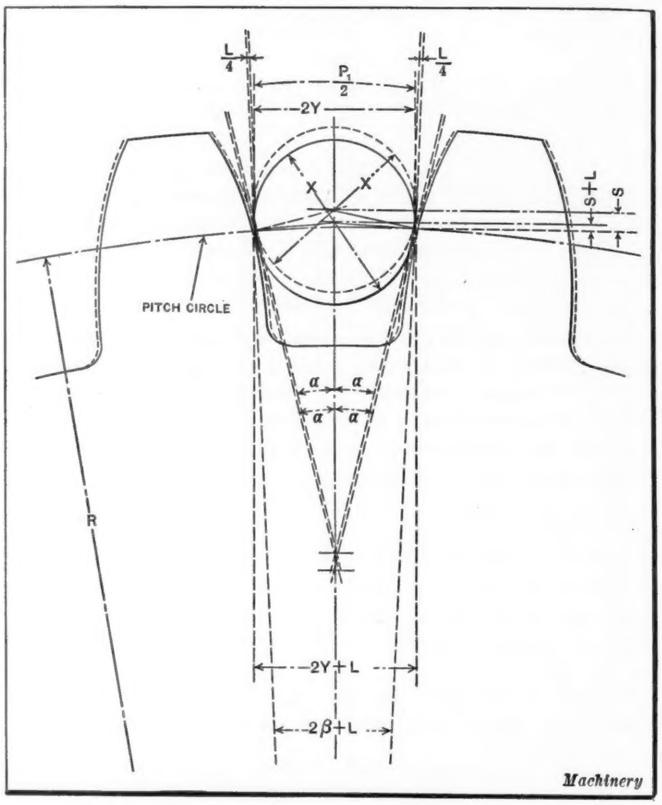

Fig. 5. Pin Measurement for Backlash

With 0.001 inch backlash, for the 30-tooth gear:

$$S_1 = \sqrt{0.075625 - 0.068618} = 0.08370 \text{ inch} \qquad (10)$$

and for the 33-tooth gear:

$$S_1 = \sqrt{0.075625 - 0.068628} = 0.08365 \text{ inch} \qquad (10)$$

With 0.005 inch backlash, for the 30-tooth gear:

$$S_1 = \sqrt{0.075625 - 0.069143} = 0.08051 \text{ inch} \qquad (10)$$

and for the 33-tooth gear:

$$S_1 = \sqrt{0.075625 - 0.069147} = 0.08048 \text{ inch} \qquad (10)$$

With no backlash, for the 30-tooth gear:

$$U = 4.99315 + 0.08449 = 5.07764 \text{ inches} \qquad (11)$$

and for the 33-tooth gear:

$$U = 5.49379 + 0.08452 = 5.57831 \text{ inches} \qquad (11)$$

With 0.001 inch backlash, for the 30-tooth gear:

$$U = 4.99310 + 0.08370 = 5.07680 \text{ inches} \qquad (11)$$

and for the 33-tooth gear:

$$U = 5.49373 + 0.08365 = 5.57738 \text{ inches} \qquad (11)$$

With 0.005 inch backlash, for the 30-tooth gear:

$$U = 4.99305 + 0.08051 = 5.07356 \text{ inches} \qquad (11)$$

and for the 33-tooth gear:

$$U = 5.49373 + 0.08048 = 5.57421 \text{ inches} \qquad (11)$$

For the 33-tooth gear, with no backlash:

$$O = 5.57831 \times 0.09506 = 0.530274 \text{ inch} \qquad (12)$$

For the 33-tooth gear, with 0.001 inch backlash:

$$O = 5.57738 \times 0.09506 = 0.530196 \text{ inch} \qquad (12)$$

and with 0.005 inch backlash:

$$O = 5.57421 \times 0.09506 = 0.529884 \text{ inch} \qquad (12)$$

For the 33-tooth gear, with no backlash:

$$H = 0.530274 \times 10.472 = 5.553029 \text{ inches} \qquad (13)$$

For the 33-tooth gear, with 0.001 inch backlash:

$$H = 0.530196 \times 10.472 = 5.552213 \text{ inches} \qquad (13)$$

and with 0.005 inch backlash:

$$H = 0.529884 \times 10.472 = 5.548945 \text{ inches} \qquad (13)$$

With no backlash, for the 30-tooth gear:

$$W_1 = 2 \times 5.07764 = 10.15528 \text{ inches} \qquad (14)$$

and for the 33-tooth gear:

$$W_1 = \sqrt{0.28119052 + 123.906708} = 11.14396 \text{ inches} \qquad (15)$$

With 0.001 inch backlash, for the 30-tooth gear:

$$W_1 = 2 \times 5.0768 = 10.1536 \text{ inches} \qquad (14)$$

and for the 33-tooth gear:

$$W_1 = \sqrt{0.28110780 + 123.867804} = 11.14221 \text{ inches} \qquad (15)$$

With 0.005 inch backlash, for the 30 tooth gear:

$$W_1 = 2 \times 5.07356 = 10.14712 \text{ inches} \qquad (14)$$

and for the 33-tooth gear:

$$W_1 = \sqrt{0.28077705 + 123.724577} = 11.13576 \text{ inches} \qquad (15)$$

SIZES OF PINS USED IN MEASUREMENT OF 1 D. P. GEARS

Number of Teeth	Pressure Angle 14 Degrees, 30 Minutes		Pressure Angle 20 Degrees		Number of Teeth	Pressure Angle 14 Degrees, 30 Minutes		Pressure Angle 20 Degrees	
	Pin Diameter	Over-all Diameter	Pin Diameter	Over-all Diameter		Pin Diameter	Over-all Diameter	Pin Diameter	Over-all Diameter
12	1.6179	13.9199	1.6668	14.1339	57	1.6222	58.9805	1.6713	59.1986
13	1.6183	14.8341	1.6673	15.0431	58	1.6222	60.0066	1.6713	60.2212
14	1.6189	15.9359	1.6679	16.1502	59	1.6221	60.9834	1.6713	61.1973
15	1.6195	16.8594	1.6686	17.0725	60	1.6223	62.0074	1.6714	62.2221
16	1.6199	17.9486	1.6689	18.1628	61	1.6222	62.9920	1.6713	63.2110
17	1.6203	18.8798	1.6693	19.0938	62	1.6224	64.0063	1.6715	64.2241
18	1.6204	19.9576	1.6695	20.1718	63	1.6224	64.9669	1.6715	65.1801
19	1.6204	20.8894	1.6695	21.1081	64	1.6225	66.0104	1.6716	66.2246
20	1.6208	21.9649	1.6699	22.1794	65	1.6224	66.9701	1.6716	67.1863
21	1.6211	22.9147	1.6702	23.1282	66	1.6223	68.0093	1.6714	68.2240
22	1.6211	23.9710	1.6704	24.1854	67	1.6224	69.0205	1.6715	69.2325
23	1.6212	24.9164	1.6707	23.1324	68	1.6224	70.0269	1.6716	70.2255
24	1.6213	25.9754	1.6704	26.1900	69	1.6225	70.9672	1.6716	71.1837
25	1.6214	26.9230	1.6705	27.1376	70	1.6225	72.0113	1.6716	72.2258
26	1.6214	27.9800	1.6704	28.1949	71	1.6222	72.9784	1.6713	73.1909
27	1.6215	28.9369	1.6705	29.1507	72	1.6223	74.0120	1.6715	74.2267
28	1.6216	29.9831	1.6705	30.1977	73	1.6222	74.9844	1.6713	75.1973
29	1.6216	30.9423	1.6704	31.1557	74	1.6222	76.0126	1.6713	76.2278
30	1.6217	31.9862	1.6708	32.2008	75	1.6224	77.0302	1.6715	77.2422
31	1.6218	32.9573	1.6710	33.1704	76	1.6223	78.0142	1.6714	78.2282
32	1.6219	33.9897	1.6709	34.2038	77	1.6224	79.0069	1.6716	79.2187
33	1.6219	34.9592	1.6709	35.1743	78	1.6224	80.0083	1.6716	80.2271
34	1.6218	35.9913	1.6709	36.2059	79	1.6224	81.0389	1.6714	81.2613
35	1.6221	36.9434	1.6712	37.1596	80	1.6224	82.0109	1.6715	82.2291
36	1.6220	37.9935	1.6711	38.2082	81	1.6224	83.0203	1.6715	83.2350
37	1.6220	39.0097	1.6712	39.1885	82	1.6223	84.0114	1.6714	84.2267
38	1.6220	39.9963	1.6711	40.2107	83	1.6225	85.0660	1.6717	85.2788
39	1.6221	40.9669	1.6712	41.1825	84	1.6223	86.0135	1.6715	86.2286
40	1.6221	41.9974	1.6712	42.2119	85	1.6225	87.0445	1.6716	87.2608
41	1.6220	42.9823	1.6711	43.2014	86	1.6222	88.0143	1.6713	88.2286
42	1.6220	43.9985	1.6712	44.2134	87	1.6223	88.9796	1.6715	89.1987
43	1.6221	44.9727	1.6713	45.1880	88	1.6225	90.0147	1.6716	90.2292
44	1.6220	45.9997	1.6712	46.2146	89	1.6222	91.0297	1.6713	91.2389
45	1.6222	46.9872	1.6713	47.2022	90	1.6224	92.0119	1.6715	92.2300
46	1.6221	48.0016	1.6712	48.2161	91	1.6222	92.9743	1.6713	93.1955
47	1.6223	48.9776	1.6714	49.1915	92	1.6225	94.0166	1.6717	94.2309
48	1.6222	50.0050	1.6713	50.2189	93	1.6225	95.0353	1.6716	95.2535
49	1.6221	51.0005	1.6713	51.2123	94	1.6225	96.0156	1.6716	96.2301
50	1.6222	52.0031	1.6713	52.2174	95	1.6226	97.0651	1.6718	97.2769
51	1.6222	52.9937	1.6714	53.2087	96	1.6224	98.0129	1.6715	98.2310
52	1.6223	54.0055	1.6714	54.2199	97	1.6223	99.0448	1.6714	99.2494
53	1.6222	54.9732	1.6713	55.1849	98	1.6223	100.0143	1.6715	100.2296
54	1.6223	56.0066	1.6713	56.2206	99	1.6225	100.9448	1.6717	101.1635
55	1.6223	56.9804	1.6714	57.1977	100	1.6224	102.0118	1.6716	102.2304
56	1.6223	58.0083	1.6715	58.2227	...	......	....	......	....

Machinery

With no backlash, for the 30-tooth gear:

$$W = 10.15528 + 0.55 = 10.70528 \text{ inches} \quad (16)$$

and for the 33-tooth gear:

$$W = 11.14396 + 0.55 = 11.69396 \text{ inches} \quad (16)$$

With 0.001 inch backlash, for the 30-tooth gear:

$$W = 10.15360 + 0.55 = 10.70360 \text{ inches} \quad (16)$$

and for the 33-tooth gear:

$$W = 11.14221 + 0.55 = 11.69221 \text{ inches} \quad (16)$$

With 0.005 inch backlash, for the 30-tooth gear:

$$W = 10.14712 + 0.55 = 10.69712 \text{ inches} \quad (16)$$

and for the 33-tooth gear:

$$W = 11.13576 + 0.55 = 11.68576 \text{ inches} \quad (16)$$

The general formulas governing the pin measurement of spur gears are, with the exception of the pin diameter, quite independent of the pressure angle and scarcely require further explanation, for the general formulas and those applying to specific instances can be readily followed by reference to the illustrations. The principal consideration is the accuracy of the method, and this is best illustrated by the consideration of a concrete example; Example 2 is quite typical and gives the calculations required for ascertaining the distance between centers and over pins for 30- and 33-tooth gears, of 3 diametral pitch, with 20-degree teeth; first, without backlash; second, with 0.001 inch backlash, and, third, with 0.005 inch backlash. The greater backlash is not excessive and is frequently found necessary for gears of ordinary pitch.

In explanation of the choice of pin diameter, the fact that the maximum chordal width of tooth space with 0.005 inch backlash equals 0.5259 inch must be taken into consideration in selecting the diameter of the measuring pin. The diameter of the pin selected is 0.55 inch, which is greater than the chordal width of the tooth space, but less than the product of half the chordal width multiplied by the secant of the pressure angle.

The presence of 0.001 inch backlash in a 30-tooth, 3-diametral pitch gear is quite apparent by the pin method of measurement, although it could not very well be measured in any other way. It is shown by a difference in measurement of about 0.0016 inch, while a 0.005 inch backlash, an amount which is frequently allowed, makes a difference of approximately 0.0078 inch. A backlash of 0.01 inch would be apparent by a reduction in diameter of 0.0156 inch. This multiplication of backlash in pin-measurement readings is one of the chief advantages of the system, for it eliminates the necessity of the careful micrometric readings, which would be about the only other way in which such small variations between the thickness of the teeth and the width of the tooth spaces could be measured.

In the case of the 33-tooth gear, or any gear with an odd number of teeth, the variation in measurement is not quite so proportionately pronounced, as the measurement is made on a chord slightly shorter than a diameter, so that the variations are proportionately reduced. Owing to the fact that all teeth may not be quite uniformly proportioned in a gear, more than one pin measurement is always advisable, particularly in the case of gears with an odd number of teeth. The various measurements should also be made from or between different sets of teeth, so as to obtain a reliable average.

The accompanying table gives the pin diameter of gears of 1 diametral pitch having from 12 to 100 teeth, with 14.5- and 20-degree pressure angles. It also gives the diameter of the gears when measured over the pins.

TOOLING A FOREIGN CAR IN AMERICA

THE REAR AXLE HOUSING

BY THOMAS ORCHARD [1]

IN this and following articles will be described some interesting jigs and fixtures used in tooling an automobile of foreign design. This car was originally built by Russian engineers, who employed hand methods, and it became evident that in order to increase the production a change would have to be made in their methods of manufacture. Accordingly contracts were made with concerns in America to provide them with jigs and fixtures for interchangeable manufacture, which were designed by American engineers in accordance with modern practice. The tooling of the rear axle housing, crankcase, piston ring and connecting-rod will be explained. The present article takes up the machining of the rear axle housing.

Oper. No.	Operation	Type of Machine	Tools
1	Clean casting	Sand blast	
2	Anneal and pickle	Annealing furnace	
3	Mill surface of joint (rough and finish) and burr	Beaman & Smith continuous milling machine	Fixture for holding four pieces
4	Face-mill eight bolt bosses	Becker vertical milling machine	Plate with locating pins and clamps
5	Drill eight bolt holes in flange and ream two holes for locating	No. 14 "Natco" multiple-spindle drilling machine	Trunnion jig
6	Rough straddle-mill inside and outside of main bearings and bosses surrounding. Allow for finish cut	Le Blond milling machine	Fixture, cutters and arbor
7	Assemble the two halves	Bench	Bolts
8	Bore (rough and finish) and size 133-millimeter diameter bearing holes; finish face, inside and outside (except bosses); index work 90 degrees and bore (rough and finish) and size 130-millimeter diameter hole; rough- and finish-face flange at same end	Universal boring machine	Indexing table. Boring fixture, bars and cutters
9	Turn out and size recess for rear axle tube on one side; reverse and recess other side	No. 7A Potter & Johnston turret lathe	Fixture
10	Drill ten holes in each side of case; drill six holes in end	No. 14 "Natco" multiple-spindle drilling machine	Trunnion jig
11	Tap twenty 12-millimeter holes	No. 30 "Natco" multiple-spindle drilling machine	
12	Tap six 10-millimeter holes	No. 30 "Natco" multiple-spindle drilling machine	
13	Drill hole, counterbore end of boss and tap 22-millimeter hole	Rockford horizontal drilling machine	Fixture
14	Drill hole, face boss and tap 30-millimeter hole	Rockford horizontal drilling machine	Same fixture as used for Operation 13
15	Wash in soda solution		
16	Inspection		

Machinery

By glancing through the various operations necessary to machine the rear axle housing, it can readily be seen that most of the jigs and fixtures are very simple affairs which do not involve any points of special interest. However, the designing of the jig for Operation 10 brought out some interesting methods of tooling. This operation is performed in a trunnion jig and involves the drilling of twenty holes, half of which are located on opposite sides of the housing, and six holes located at right angles to the twenty holes.

The rear axle housing, Fig. 1, is loaded in a trunnion jig *A*, Figs. 2 and 5, in the position shown. Part *A* is revolved in two bearings, or supports, *B* and *C*, at each end, which are set on the base *D*. These parts are all of cast iron, while the pins *E* on which the revolving takes place are of steel, pressed into *A*, and having a running fit in *B* and *C*. The supports *B* and *C* are tongued in the base by means of the keys *F*, to insure proper alignment. Support *B* is bolted permanently to the base, while support *C* may be adjusted in either direction, should the revolving part *A* turn too hard, or should there be any wear at *G* and *H*. The adjustment is made by the set-screws *J* and *K* after loosening the nuts *L* and *M*, elongated slots being provided to permit this adjustment. The base *D* is equipped with six steel wheels *N* and runs on a track under the spindles of two "Natco" multiple-spindle drilling machines; one of the machines is set up for drilling the ten holes on opposite sides of the work, and the other for the six holes on the end.

The revolving part *A* has a disk A_1 on each end, these disks being a part of the casting itself. They revolve with part *A*, their purpose being to relieve the pins *E* of the entire weight when revolving. The outside diameters of these wheels are finished and they ride on cast-iron shoes *P*, which rest on supports *B* and *C*, and are held in place by means of the screws and dowels *Q* and *R*. The friction of the disks A_1 on the shoes *P* also serves, to a certain extent, as a brake while revolving the jig, and prevents the operator from losing control of it when the indexing plunger is not in place.

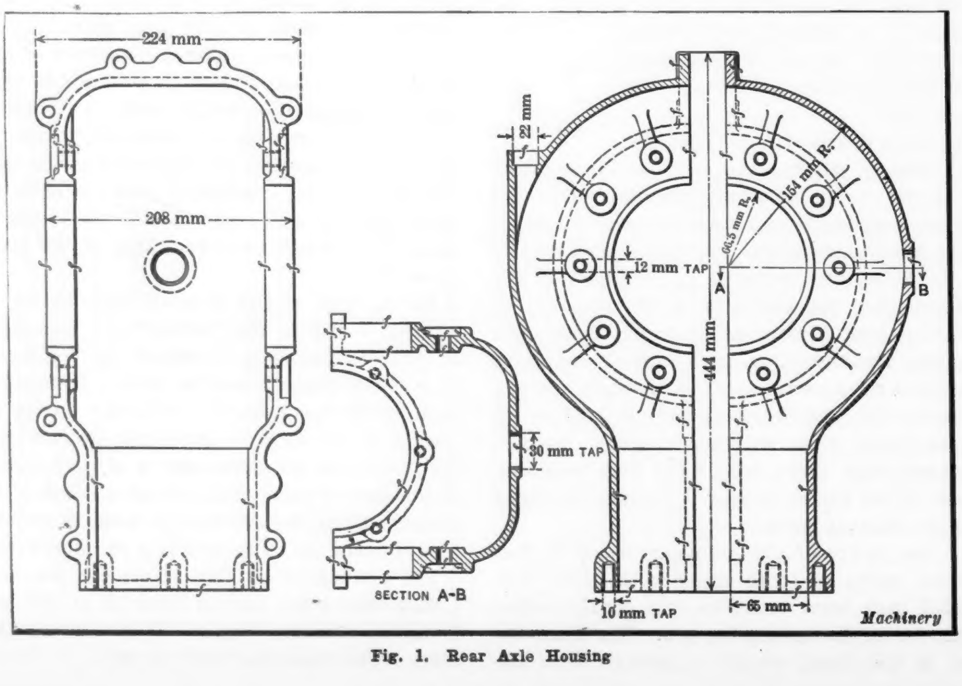

Fig. 1. Rear Axle Housing

Loading the Jig

As previously stated, Figs. 2 and 5 show the jig in the loading position. To load, the clamping arrangement contained in strap *S* is removed, and plug *T* is pulled back into the counterbored hole *U*, by means of handle *V*. The locating plug *W* is drawn back until pin *X* clears the top of boss *Y*. It is then given a quarter turn, spring *Z* bringing the pin in contact with boss *Y*, thus keeping plug *W* in the clear. The work may now be inserted from the top in the position shown in Fig. 1, and the 133-millimeter hole slipped over the locating plug B_1, which is pressed into the wall of the jig *A*.

The plug *T* is then pushed inward, fitting into the corresponding hole on the opposite side of the work, until the shoulder on the plug rests against the finished boss on the work. In order to allow ample loading and unloading clearance between the side walls of the jig, it was found necessary to devise a quick clamping device to be used in conjunction with plug *T*, in order to save time in pulling this plug back out of the way and moving it forward to clamp the work. The following method was used. A plate C_1, with a slot D_1 cut in it to allow the pin E_1 to pass through it, was screwed in position on top of the boss F_1.

[1] Address: New Britain Machine Co., New Britain, Conn.

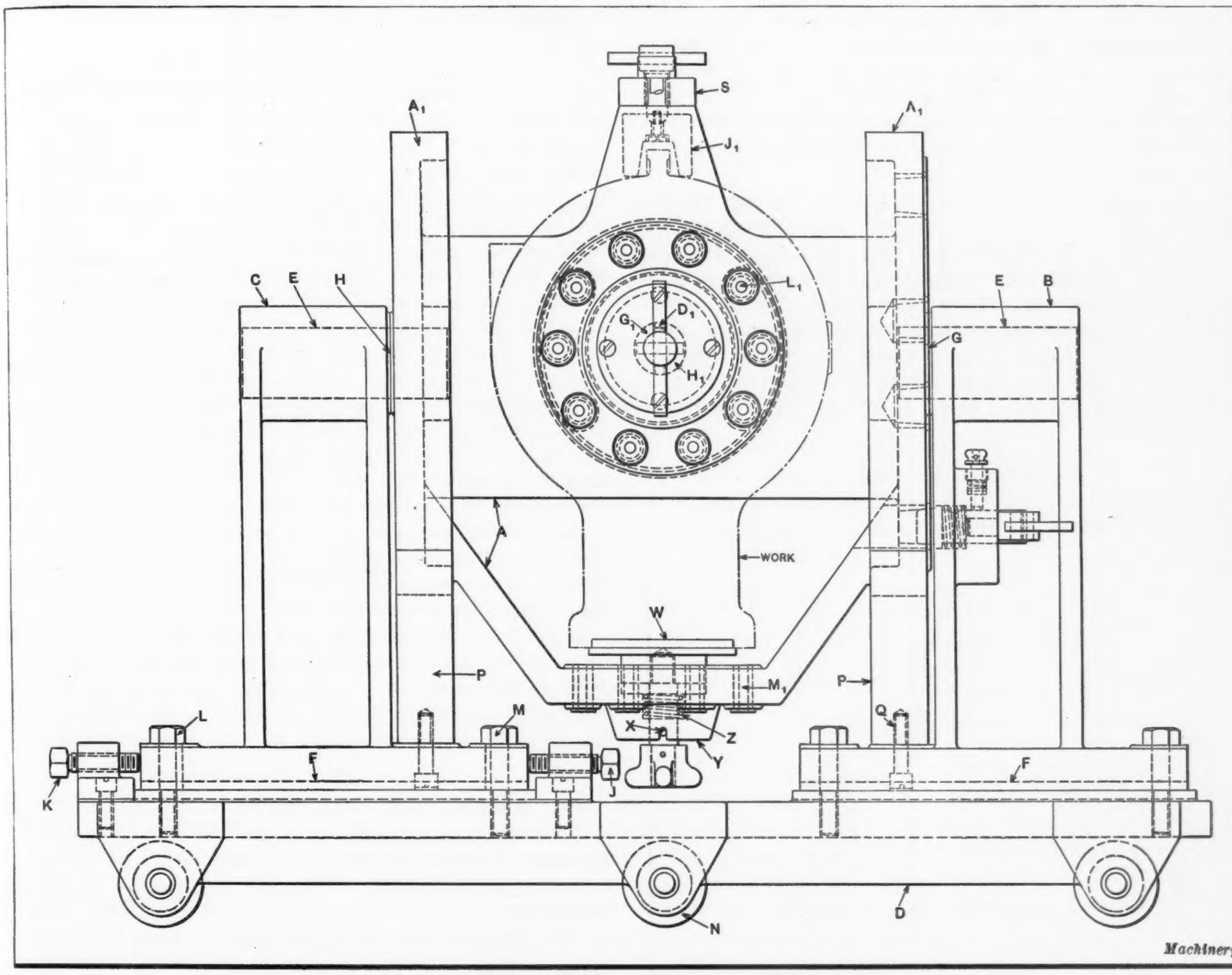

Fig. 2. Side Elevation of Trunnion Jig

Two plates G_1 and H_1 were set in a counterbored hole in the bottom of C_1, these plates being cut at an angle. To pull plug T back from the work, handle V is turned 90 degrees, thus allowing pin E_1 to pass up between the two plates G_1 and H_1 and through the slot D_1 in the plate C_1. Handle V is again turned 90 degrees and plug T is held back in the counterbored hole U by pin E_1 resting on top of plate C_1. When loading, a reverse method is employed to get plug T into the 133-millimeter hole in the work, after which the work is clamped by the cam action of pin E_1 against G_1 and H_1 as handle V is turned. This not only gives the work horizontal alignment, but clamps it in place as well. As soon as the work has been slipped over plug B_1, W may be allowed to spring upward, and as T is inserted in the work, W will find

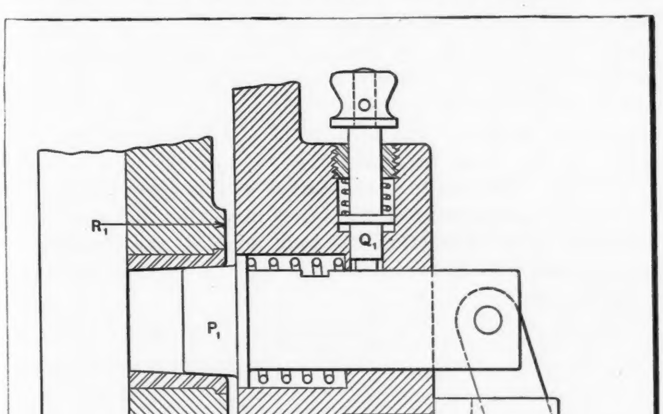

Fig. 3. Indexing Plunger engaged with Trunnion Jig

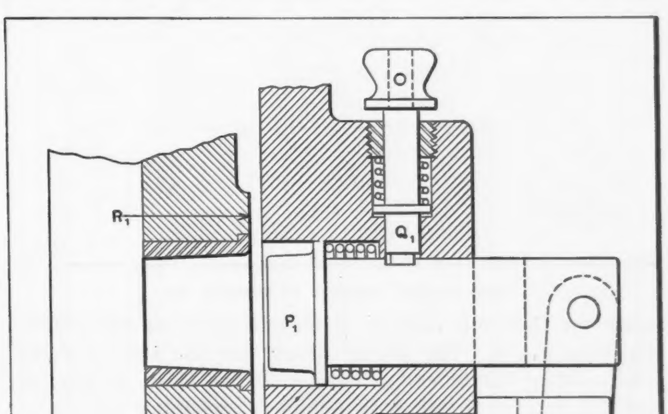

Fig. 4. Indexing Plunger withdrawn from Trunnion Jig

its place in the 130-millimeter hole, thus taking care of the vertical alignment. Strap *S* is then locked on the jig by means of quarter-turn screws and the equalizing clamp J_1 brought down against the work. This clamp is free to rock in any direction and adjusts itself to any irregularities there may be on the rough casting. The method of obtaining this result is clearly shown in Fig. 6.

The jig may now be revolved or indexed 90 degrees and run along the track under a "Natco" drilling machine, in which the ten holes are drilled at once by a bank of drills arranged for this particular operation. The fixture may then be indexed 180 degrees and the ten holes L_1, Fig. 2, drilled under the same machine, as their location is identical with the corresponding holes on the opposite side of the housing. The fixture is then run along the track and under another "Natco" drilling machine, which is set up for drilling the six holes M_1.

Indexing the Jig

The method of indexing is very simple and is shown in Figs. 3 and 4. When the work is to be revolved, the lever N_1

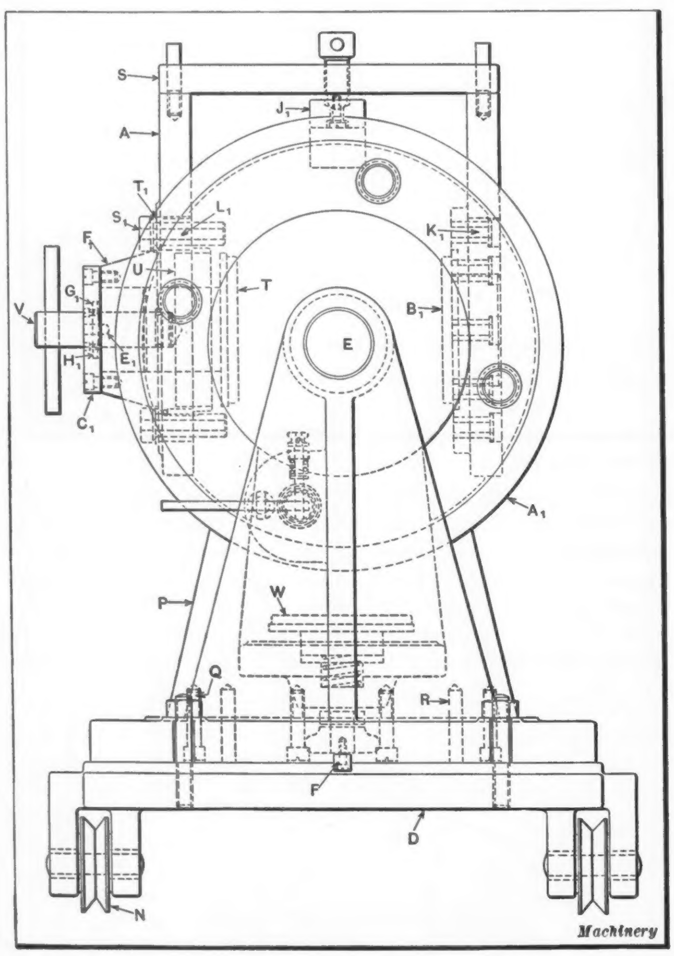

Fig. 5. End Elevation of Trunnion Jig

raises the indexing plunger P_1 until it assumes the position shown in Fig. 4. The pin Q_1 drops into the slot as shown, thus holding the indexing plunger in the clear, so that the operator is free to use both hands in revolving the fixture. As soon as the fixture starts to revolve, pin Q_1 may be raised, allowing plunger P_1 to spring forward and ride against the finished surface R_1. As the next hole is indexed around, the plunger will automatically drop into place.

Slip Bushings

The most important feature of this jig was the discovery of a method whereby a slip bushing could be made a permanent part of the jig rather than a loose piece. This method can be applied to slip bushings in almost any jig to great advantage, due to the fact that loose pieces in a jig are often mislaid and sometimes lost. It was necessary in this particular case to draw the slip bushings S_1, Fig. 5, back, in order to get clearance for loading and unloading, which would mean the disengaging each time of whatever locking device was used in order to keep the bushings from falling out as the jig was revolved. This difficulty was overcome by a method that is shown in Fig. 7. A hole was drilled in the liner bushings T_1 and a steel ball U_1 inserted, with a spring V_1 behind it. A slot W_1 was cut in the slip bushings to receive the steel ball. Owing to the location of the hole to be drilled in the work, the slip bushing must be in the position shown at *B* when the work is removed or placed in the jig. However, the ball and spring in the liner bushing prevent the slip bushing from falling out or being removed. After the work has been clamped in the jig, the slip bushing being in the position shown at *B*, the drill will, on entering the bushing, carry it down until it assumes the position shown at *A*. After the hole has been drilled, the slip bushing will be carried back by the friction of the drill to the position shown at *B*, thus automatically leaving clearance for loading and unloading the jig. The spring pressure behind the ball in the liner bushing holds the slip bushing in this position until the drill again carries it down when the holes are being drilled in the next piece. The travel required for clearance in removing the work from the jig should correspond to the length of the slot in the slip bushing. Taking into consideration the amount of work accomplished in this jig, it should not be considered an expensive arrangement.

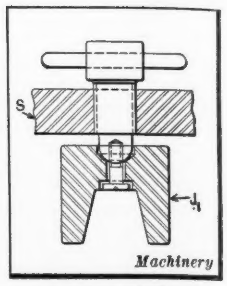

Fig. 6. Detail of Equalizing Clamp

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AMERICAN GRAPHITE DEPOSITS

According to a pamphlet published by the United States Geological Survey, the largest graphite mines in the world producing the best quality of mineral graphite are in Ceylon, though there are great deposits in Mexico and Korea. Before the war, the clay with which the graphite must be combined in the making of crucibles came from Bavaria, where there are also extensive graphite mines. Cut off from Ceylon, the Germans have made Bavarian graphite serve them, but, on the other hand, cut off from Bavaria, American manufacturers have succeeded in developing clay beds at home that furnish the material for making as good crucibles as those made of Bavarian clay.

The largest American graphite mines are in Alabama, Alaska, California, Colorado, Michigan, Montana, Nevada, Texas, Washington, New York, Pennsylvania, North Carolina and Rhode Island. At Niagara Falls, graphite is also made in the electric furnaces. In 1915, the total American mine production of amorphous (finely divided) graphite was 1181 tons; and of crystalline graphite, 3500 tons. In 1916, the total of amorphous graphite was 2622 tons, and of crystalline, 5465 tons. To this must be added 2542 tons of artificial graphite in 1915 and 4199 tons in 1916. But it will be some time before we become independent of the mines in Ceylon and elsewhere, for while home production has been doubled, the demand for graphite has also increased so that imports in 1916 amounted to 42,930 tons.

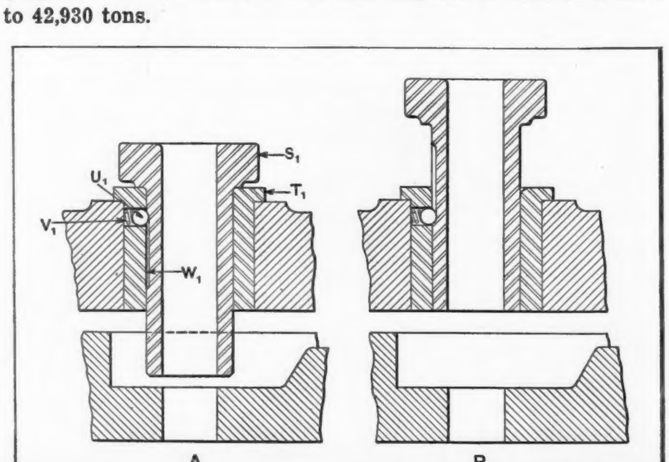

Fig. 7. Method of securing Slip Bushings to Jig

THREAD MILLING[1]

GENERAL APPLICATION AND ADVANTAGES OF MILLING PROCESS—DIFFERENT METHODS OF FORMING SCREW THREADS BY MILLING—VARIOUS TYPES AND DESIGNS OF THREAD MILLING MACHINES AND ATTACHMENTS

BY FRANKLIN D. JONES[2]

THE formation of screw threads by means of a rotating cutter or by the milling process has been practiced for nearly half a century, but the real development of thread milling is relatively modern as marked by the introduction of efficient machines constructed especially for doing this work on a manufacturing basis. A great many screw threads that formerly were cut with a single-pointed tool in an engine lathe are now milled. Thread milling has also proved superior to the use of dies or taps for certain external and internal screw-cutting operations. Before considering the relative advantages of the thread-milling process as compared with other screw-cutting methods and the particular classes of work for which thread milling is especially adapted, the different methods of forming screw threads by milling and various types of thread milling machines and attachments will be described.

Milling Threads with Single Cutter

There are two general methods of forming screw threads by milling, which may be designated as the single-cutter and the multiple-cutter methods. The way a single cutter is used is indicated by the diagram Fig. 1. The profile of the cutter or the shape of its cutting edge conforms to the sectional shape of the thread groove. This cutter should revolve as fast as possible without dulling the cutting edges excessively, in order to mill a smooth thread and prevent unevenness such as would result with a slow-moving cutter on account of the tooth spaces. As the cutter rotates, the part on which a thread is to be milled is also revolved, but at a very slow rate (a few inches per minute), since this rotation of the work is practically a feeding movement. The cutter is ordinarily set to the full depth of the thread groove and finishes a single thread in one passage, although deep threads of coarse pitch may need two or even three cuts. For work of this kind a roughing cut is sometimes taken with a special cutter which is somewhat narrower than the finishing cutter.

Whenever a single cutter is used, the axis of the cutter is inclined to some angle a instead of being parallel to the axis of the screw, in order to locate the cutter in line with the thread groove at the point where the cutting action takes place. (Tangent of angle a = lead of screw thread $\div$ pitch circumference of screw.) The helical or "spiral" thread groove is generated in practically the same way as when an engine lathe is used. In the case of a thread milling machine, however, the lengthwise traversing movement is applied to the cutter on some machines and to the screw being milled on other machines. For instance, the revolving cutter may be traversed in a direction parallel to the axis of the work a distance equal to the lead of the thread for each revolution of the screw blank, or this order may be reversed, the cutter revolving in one position while the screw blank moves in a lengthwise direction as it slowly rotates. These variations in the design of different thread milling machines will be considered later. The single cutter process is especially applicable to the milling of large screw threads of coarse pitch, multiple threads, and the heavier classes of work. For fine pitches and short threads the multiple-cutter method to be described is preferable, because it is more rapid.

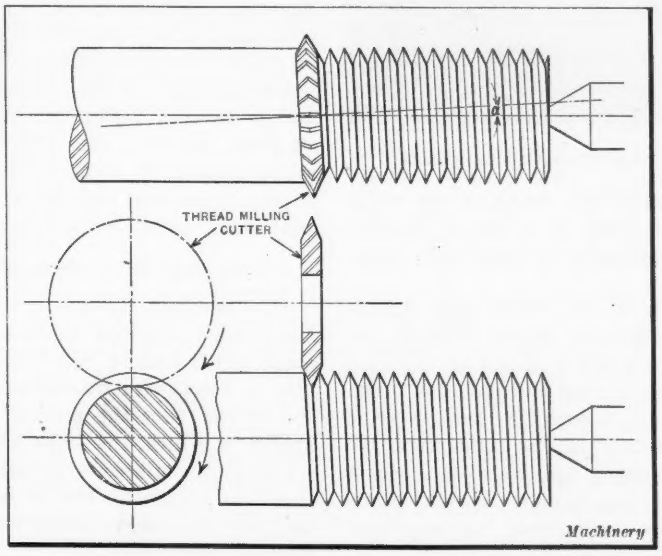

Fig. 1. Diagram illustrating Method of milling Screw Thread with a Single Cutter

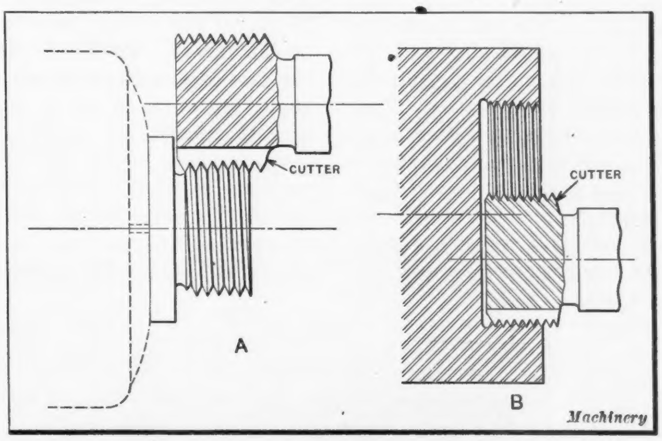

Fig. 2. Examples of External and Internal Thread Milling with a Multiple Type of Cutter

Milling Threads with Multiple Cutter

The second thread milling method referred to, which requires the use of a multiple cutter, is illustrated by the diagrams A and B, Fig. 2. This multiple cutter is practically a series of single cutters, although formed of one solid piece of steel, at least so far as the cutter proper is concerned. The annular rows of teeth do not lie in a helical or spiral path, like the teeth of a hob or tap, but coincide with planes which are perpendicular to the axis of the cutter. If the cutter had helical teeth the same as a hob, it would have to be geared to revolve in a certain fixed ratio with the screw being milled, but a cutter having annular teeth may rotate at any desired speed, while the screw blank is rotated slowly to provide a suitable rate of feed. (The multiple cutters used for thread milling are frequently called "hobs," but in this article the term hob will be applied only to cutters having helical teeth.)

The object of using a multiple cutter instead of a single cutter is to finish a screw thread complete in approximately one revolution of the work, a slight amount of over-travel being allowed to insure milling the thread to the full depth where the cut joins the starting point. In order to finish the thread complete in one revolution (plus the over-travel referred to), it is necessary to use a cutter which is at least one or two threads or pitches wider than the thread to be milled. When using a multiple cutter it is simply fed in to the full thread depth and then either the cutter or screw blank is moved in a lengthwise direction a distance equal to the pitch of the thread. Since there is an annular row of cutting teeth for each thread groove, this movement equal to the pitch is sufficient to finish the entire thread in one revolution of the work, plus whatever additional movement there might be due to the over-travel. If an exceptionally smooth thread were required, the work might be revolved two revolutions and the cutter be traversed a distance equal to twice the pitch of the thread. During the first revolution the

[1] For information previously published on this subject, see "Tapping Machines and Attachments," in the December, 1917, number of MACHINERY, and articles there referred to.
[2] Associate Editor of MACHINERY

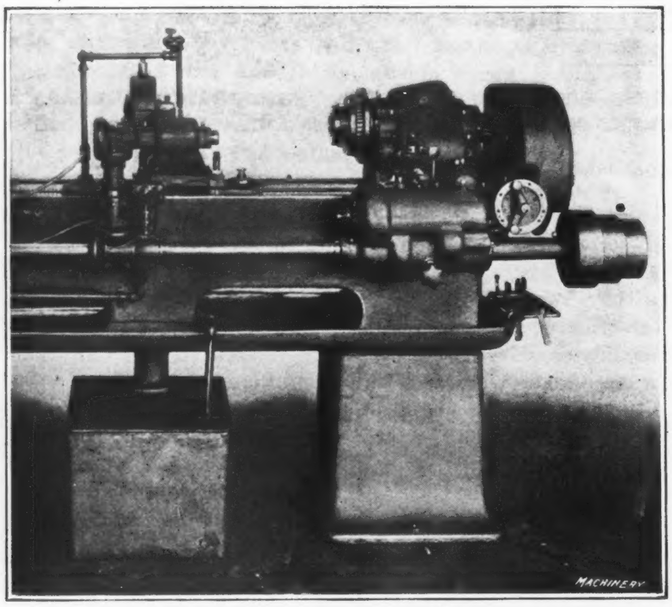

Fig. 3. Rear View of Pratt & Whitney Thread Milling Machine

thread would be rough-milled and a light finishing cut would then be taken while the work made a second revolution. Sketch *B*, Fig. 2, illustrates the application of a multiple cutter to internal thread milling.

It is apparent that the length of the thread that can be milled by the multiple-cutter method is limited, because the cutter is supported at one end only and it would be deflected considerably if the length of the cutting end and the "overhang" were increased to any great extent. As the cutter is milling along the entire screw thread at the same time, the lateral thrust is relatively large as compared with a single cutter operating on a thread of corresponding pitch; therefore, the multiple cutter is used for milling comparatively short threads and usually for medium or fine pitches.

Position of Multiple Cutter Relative to Work

When using multiple cutters either for internal or external thread milling, the axis of the cutter is set parallel with the axis of the work, instead of inclining the cutter to suit the helix angle of the thread, as when using a single cutter. Theoretically, this is not the correct position for a cutter, since each cutting edge is revolving in a plane at right angles to the screw thread while milling a thread groove of helical form. It might be supposed that there would be serious interference between the cutter and the thread, and as a result a decided change in the standard thread form. In practice, however, the defect is very slight and may be disregarded except when milling threads which incline considerably relative to the axis, as when the pitch is large in proportion to the diameter or the thread is of the multiple form and has a large helix angle. Threads which have steeper sides than the U. S. standard or Whitworth forms should ordinarily be milled with a single cutter, assuming that the milling process is preferable to other methods. For instance, when cutting an Acme thread which has an included angle between the sides of 29 degrees, there might be considerable interference if a multiple cutter were used, and for this reason the single cutter is preferable. If an attempt were made to mill a square thread with a multiple cutter, the results would be very unsatisfactory owing to the interference. If a multiple cutter, in any case, were inclined to align it with the thread groove, the same as is done when the single form of cutter is employed, the advantage of the multiple type would be lost, and instead of finishing the thread in one revolution of the screw blank, it would be necessary to traverse the cutter along the entire length of the thread.

Interference between the cutter and work is more pronounced when milling internal threads, because the cutter does not clear itself so well. Experiments have shown that multiple cutters for internal work should preferably not exceed one-third the diameter of the hole to be threaded. A cutter that is one-quarter the diameter of the thread will do very satisfactory work. It is preferable to use as small a cutter as practicable, either for internal or external work, not only to avoid interference, but to reduce the strain on the driving mechanism.

Direction of Cutter Rotation

It is the general practice when milling threads in steel, cast iron and brass to revolve the cutter and screw blank so that they are moving in opposite directions on the cutting side. For some thread milling operations, however, it is preferable to rotate the work and the cutter so that they travel in the same direction on the cutting side. For instance, when milling threads in aluminum castings, celluloid and parts made of fiber, smoother and better threads will be obtained if the cutter and work revolve together, the same as two gears in mesh, except that the cutter revolves quite rapidly, while the part being milled has a slow feeding movement.

Milling Multiple Threads with Single and Multiple Cutters

If a multiple thread is to be milled with a single cutter, the method followed is practically the same as when using a single-point tool in the lathe. The machine is arranged to give a lengthwise traversing movement equal to the lead of the thread (not the pitch), and then, after a single thread groove is milled, the screw blank is indexed a half revolution for milling the second thread groove, assuming that a double thread is required. Thread milling machines and attachments are commonly provided with means for indexing when cutting multiple screw threads.

Multiple threads can readily be milled with the multiple style of cutter, although in some cases difficulty may be experienced due to interference between the cutter and the sides of the thread. Such interference is more likely to occur in the case of a multiple thread on account of the increased helix angle. In order to mill a multiple thread, it is simply necessary to arrange the machine so that the work is advanced a distance equal to the lead of the thread instead of the pitch, the same as when using a single cutter for milling a multiple thread. In other words, the advance movement of the cutter or work, as the case may be, should be equivalent to the distance that one of the single threads advances in a complete

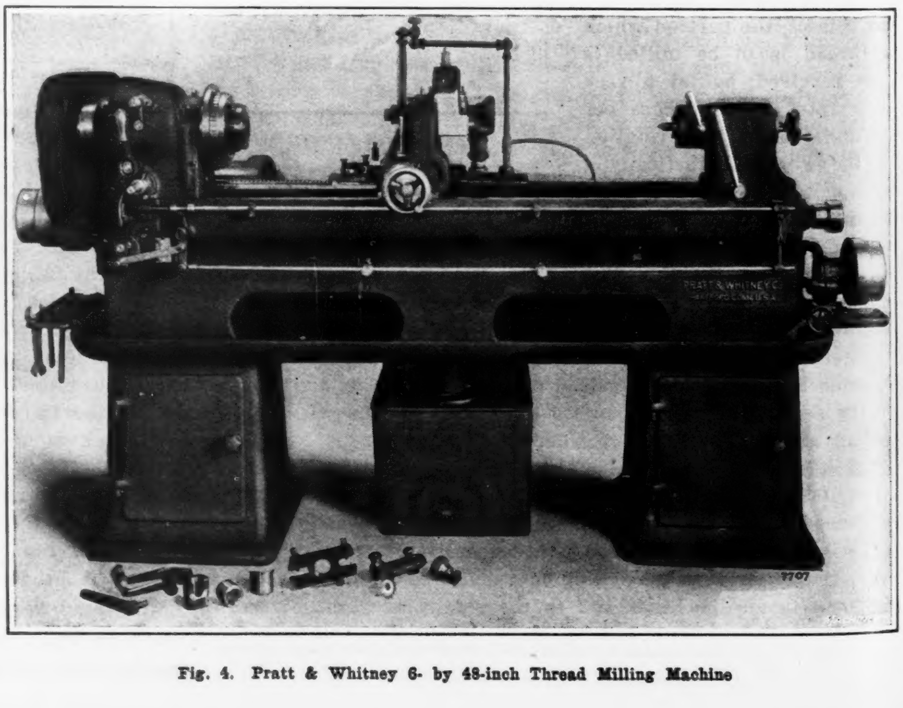

Fig. 4. Pratt & Whitney 6- by 48-inch Thread Milling Machine

turn. Another way to cut a multiple thread would be to use a cutter having a pitch equal to one-half the pitch of the lead-screw, assuming that the machine was of a type controlled by the direct action of the lead-screw on the spindle.

Types of Thread Milling Machines

Thread milling machines may be classified according to the kind of cutter used, that is, whether single or multiple, and also with reference to the method of obtaining a lengthwise feeding movement for generating the thread. Some machines are so designed that the cutter-slide or carriage is traversed along a horizontal bed by a lead-screw which is connected to the work-spindle through change-gears, the arrangement being practically the same as on an engine lathe. With this general type of machine, the cutter (which may be single or multiple) moves along one side of the work, while the latter rotates but remains in one position. This order is reversed in another general type of milling machine which is designed to move the part on which a thread is to be milled, in an axial or lengthwise direction, while the cutter-slide remains stationary, except when it is traversed laterally or at right angles to the screw thread for moving the cutter in or out of the working position. A machine of this kind may have a work-table which is traversed by a gear-driven lead-screw, or the traversing motion may be imparted to the work-holding spindle either by the direct action of a lead-screw or by a lead-screw and gearing combined. When a lead-screw is applied directly to the work-spindle, the lead of its thread is the same as the lead of the thread to be milled, and different lead-screws are used for milling threads of different pitches. Some of these "duplicating" machines are designed especially for milling threads on large numbers of duplicate parts, and they are less complicated and cheaper than a machine equipped with change-gears and arranged for milling threads of different pitches. Other machines which derive the traversing motion directly from a lead-screw are so constructed that one lead-screw may easily be replaced with another of different pitch. Such machines are intended for general application, but lead-screws are changed for milling threads of different pitch, instead of change-gears, as in the case of the other general type of machine mentioned. Thread milling machines embodying the general principles of operation outlined differ, of course, in regard to the arrangement, as well as to the details of construction, as shown by the following descriptions.

Pratt & Whitney Thread Milling Machine

One design of thread milling machine having a gear-driven lead-screw and a traversing cutter-slide is shown in Fig. 4, which illustrates a 6- by 48-inch machine manufactured by Pratt & Whitney Co., Hartford, Conn. This machine is driven

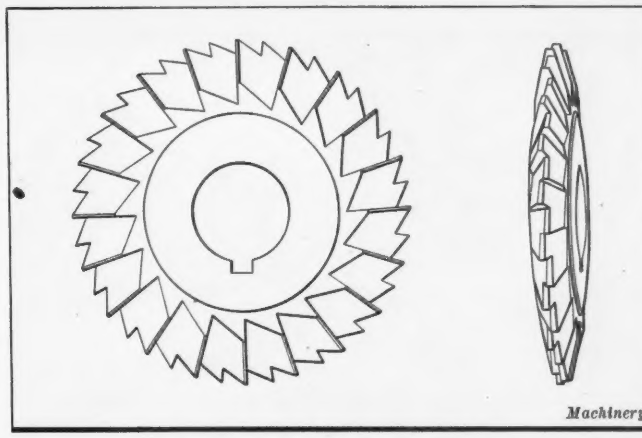

Fig. 6. Kind of Cutter used on Pratt & Whitney Thread Milling Machine

by a belt connecting with a cone pulley carried by a horizontal shaft extending along the rear side of the bed, as shown in Fig. 3. This shaft drives the work-spindle through a gear-box which provides for the necessary speed changes. The lead-screw for traversing the cutter-slide is connected to the work-spindle by change-gears selected with reference to the pitch or lead of the thread to be milled. The rear view illustrates how motion is transmitted from the driving shaft to the cutter-spindle through bevel gearing and suitable connecting shafts. The main driving shaft at the rear is splined to permit the cutter-slide to move along the bed. The cutter-slide has a rapid traversing movement and automatic stops for controlling the length to which a thread is milled.

The work-spindle is indexed when cutting multiple screw threads by a notched ring attached to the inner section of the compound work-spindle. The outer section of this spindle is normally locked to the inner part by a pawl which engages a notch in the ring referred to. In order to index a screw requiring a multiple thread, the pawl is disengaged and the inner part of the spindle is turned whatever fractional part of a revolution may be required. For instance, if a double thread were being milled, the indexing movement would equal one-half revolution, whereas for a triple thread it would be necessary to index one-third revolution, and so on. As a machine of this type is used for many other helical milling operations other than screw threads, the index ring is provided with forty-eight notches for accommodating other classes of work.

When it is necessary to mill helical grooves of exceptionally long lead, it might not always be practicable to drive the lead-screw from the work-spindle in the usual manner because of the excessive stresses to which the change-gears would be subjected. One method of avoiding this difficulty in connection with lathe practice has been to drive the work-spindle from the lead-screw. The drive can be changed in this same way when using the thread milling machine shown in Fig. 4, by simply shifting clutches which, for work of the class mentioned, make the lead-screw the driver and the work-spindle the driven member. These machines are sometimes provided with what is known as a "backing out attachment." This is simply an arrangement for gradually withdrawing the cutter at the end of a thread so that the thread groove will gradually taper from the full depth out to zero, instead of abruptly rising from the bottom to the top of the thread groove. When this attachment is in use the cutter withdraws while the work is making three turns. This method of finishing the end of a screw thread is desirable when screws are subject to severe shocks, as, for example, the screws of rock drills.

The style of milling cutter used on the Pratt & Whitney thread milling machine is shown in Fig. 6. This is a special form of cutter having staggered teeth. The teeth

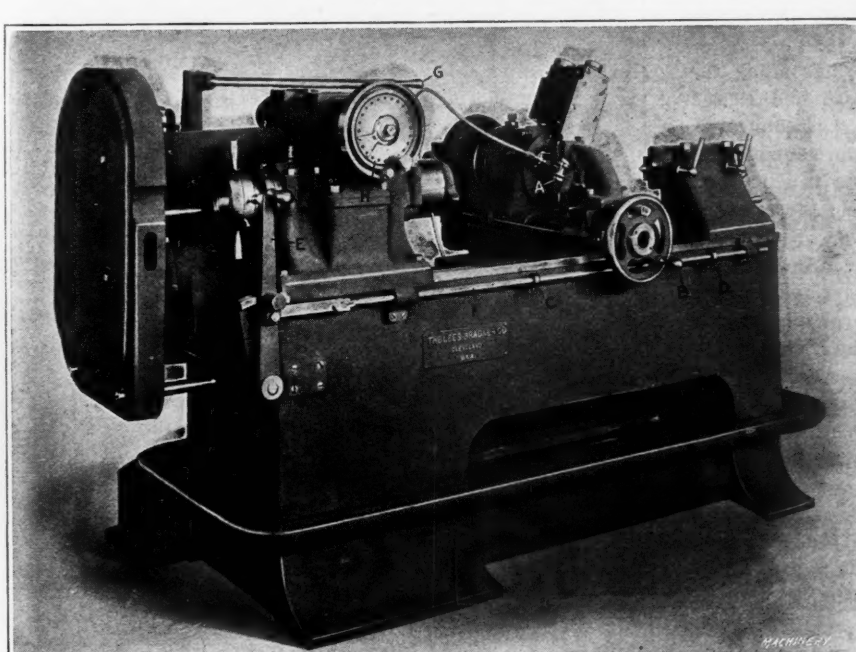

Fig. 5. Lees-Bradner Thread Milling Machine

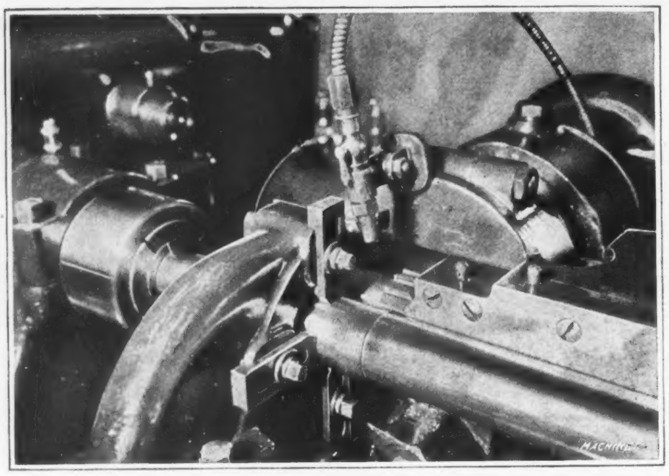

Fig. 7. Detail View of Lees-Bradner Machine milling Screw Thread with a Multiple Type of Cutter

do not extend across the cutter, but are arranged to cut only on one side, each cutting edge being midway between the adjacent edges on the other side. One tooth is left full for the purpose of gaging. The cutter is made in this way so that the oil or cutting compound has free access to the cutting edges and the chips readily escape or are washed away by the lubricant. A special automatic grinder is used for sharpening these cutters. This grinder has three wheels, two of which are for grinding the angular sides; after the sides are finished, the third wheel is used for sharpening the points of the teeth.

Lees-Bradner Thread Milling Machine

The thread milling machine shown in Fig. 5 is another example of the type which mills a screw thread by traversing a cutter along the work while the latter revolves but remains in the same lengthwise position. The change-gear mechanisms for controlling the lead of the thread to be milled, the speed of the work-spindle or the feeding movement, and the cutter speed are incorporated in the design of the headstock. All movable parts are driven from a single belt pulley at the rear. Motion is transmitted to the cutter-spindle *A* by means of a splined shaft which extends along the rear side of the bed and is connected to the cutter-spindle through suitable gearing. The cutter-head is of cylindrical design and can be swiveled 180 degrees for aligning the cutter with a thread groove or any other helical groove. The angular position of the cutter-spindle is indicated by graduations and a vernier scale. The lateral position of the cutter is controlled by handwheel *B*. The depth of the cut is indicated by a micrometer dial and it may be regulated positively by an automatic adjustable stop which is used either when milling duplicate screw threads or multiple threads.

The traversing movement of the cutter carriage along the bed may be controlled automatically by stops *C* and *D* and also by hand lever *E*, with which the trip-rod *F* is connected. The machine is idle when clutch lever *E* is in the neutral position shown in the illustration. When this lever is shifted to the right, thus engaging the positive feed clutch, the carriage travels to the left until it engages stop collar *C*, which is set in accordance with the length of thread to be milled. After the cutter is withdrawn from the work, the carriage may be rapidly returned to the starting position by throwing lever *E* to the left, which engages a friction clutch. The return movement of the carriage is arrested by collar *D*, which swings lever *E* to the neutral position again. The operating parts of the machine are started or stopped by lever *G*.

The work may be held between centers or in a collet chuck at the headstock end and on a center at the tailstock end, if this additional support is necessary. The collet chuck should be used if possible. The work may be turned independently by means of the indexing mechanism at *H*, which is used when cutting multiple screw threads or for relocating the cutter with a previously milled thread groove.

When threads of fine pitch are to be milled, a multiple form of cutter is used, instead of a single cutter, in order to finish a thread complete in practically one revolution of the spindle. The detailed view, Fig. 7, shows a multiple cutter milling a thread on one section of a spindle. The steadyrest shown in this illustration and in Fig. 5 is used for supporting all flexible parts. While this machine is designed primarily for milling such parts as lead-screws, worms, etc., it may also be employed for milling either spiral or spur gears. It is manufactured by the Lees-Bradner Co., Cleveland, Ohio.

Moline Thread Milling Machine

The machine shown in Fig. 8 differs from the designs previously described in that it has a traversing work-table and a cutter which revolves in one position when milling a thread. The work-table carries the headstock and tailstock spindles for holding the work between centers, and it is traversed at the proper rate for generating a thread of the required lead by means of change-gears, seen at the end of the machine, which connect the main or headstock spindle with the lead-screw. This machine is adapted for milling threads of coarse pitch or large worms. The cutter, of course, can be adjusted to the helix angle of the thread as well as laterally for feeding it in to the depth of the thread or away from the work. This machine has an indexing mechanism for use when cutting multiple threads. This device consists of an index plate attached to the driving gear of the main spindle and having suitable holes which are engaged by a plunger. The work may either be held between the centers, as shown in the illustration, or in a collet chuck or jaw chuck screwed onto the spindle. When parts are held between centers a steadyrest block, provided with bushings, may be used for supporting the work. This machine has a maximum swing of 8 inches and will hold parts 30 inches long between the centers. The spindle is hollow and a 3½-inch shaft may be passed through it. This machine is made by the Moline Tool Co., Moline, Ill.

Waltham Thread Milling Machine

The thread milling machine illustrated in Fig. 9 is intended for small precision work. The cutter-slide of this machine is traversed along the bed by a lead-screw connecting with the work-spindle through change-gearing. The machine is driven from a constant-speed shaft mounted in brackets on the rear side. This shaft drives the work-spindle through the cone pulleys shown and worm-gearing. The four-step cone pulleys are interchangeable and provide the necessary speed changes. The milling cutter-spindle is set at the helix angle of the thread as shown by graduations on the circular base of the swiveling member. When a thread has been milled to the required length, the machine is stopped automatically by the disengagement of a clutch on the work-spindle. Oil or some

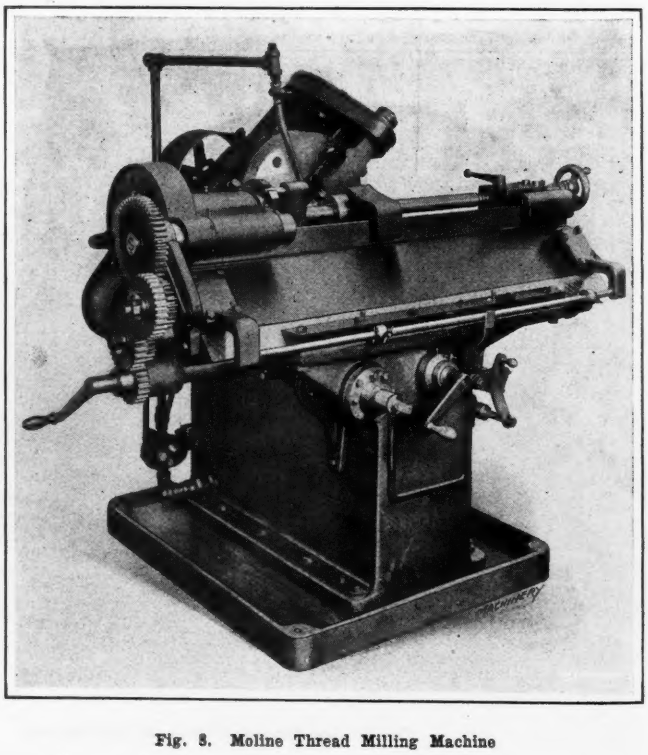

Fig. 8. Moline Thread Milling Machine

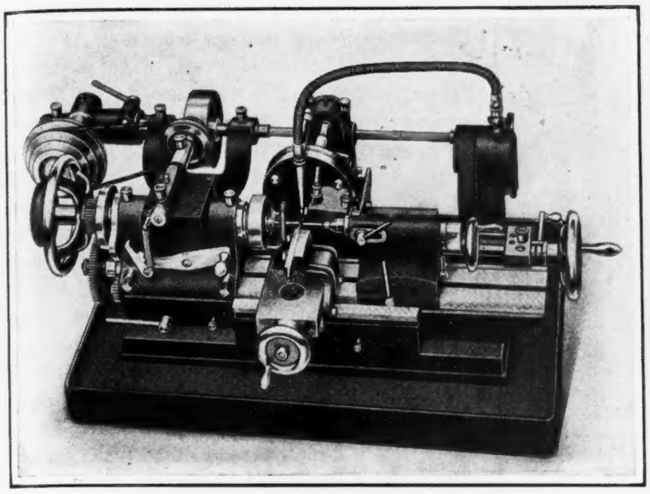

Fig. 9. Waltham Thread Milling Machine

cutting compound is supplied to the cutter by means of a pump driven from the constant-speed shaft at the rear of the machine. Tapering threads may be milled by using a taper attachment which is similar in principle to the attachment found on engine lathes. This machine also has a compensating bar for obtaining slight variations in the lead of a screw thread to compensate for shrinkage in hardening, as when making thread gages or taps. A pointer attached to the swiveling bar extends through to a graduated index at the front of the machine and shows the amount of increased lead that can be obtained. The angular position of the compensating bar can be changed by means of two thumb-screws at the front of the machine. The right-hand bearing of the lead-screw is threaded, and this bearing can be rotated by a lever to change the location of the cutter carriage in relation to the thread groove. This fine longitudinal adjustment may be used for setting the cutter to match a thread groove that has previously been milled. This machine is made by the Waltham Machine Works, Waltham, Mass., and it is intended for tool-rooms and experimental laboratories, as well as for universal use on work within its range.

Internal Thread Milling Machine of Single-cutter Type

The Pratt & Whitney internal thread milling machine shown in Fig. 10 is adapted particularly for milling threads of moderate pitch in holes varying from 1¼ inch in diameter up to about 6 inches. The work-spindle and cutter-spindle are both driven from a horizontal shaft at the rear carrying a three-step cone pulley. The speed of the work-spindle is varied by means of a gear-box at the rear of the machine, eighteen speed changes being obtained for each of the three positions of the belt on the cone pulley. The cutter-spindle is driven through gearing from the shaft referred to, and in order to eliminate any tendency on the part of the cutter to chatter owing to lost motion in the driving gears, use has been made of a fly-wheel which is mounted in bearings that are independent of

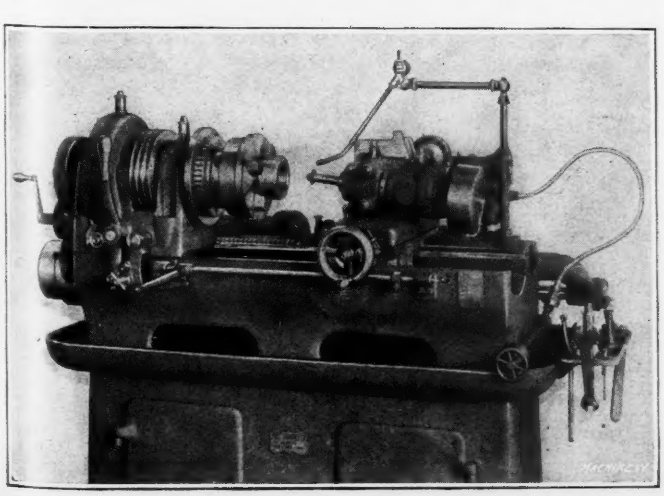

Fig. 10. Pratt & Whitney Internal Thread Milling Machine

the spindle. The cutter-spindle head is so constructed that the angular adjustment of the cutter for aligning it with the helical thread groove does not disturb the central relation between the cutter and the thread being milled. The lateral position of the cutter may be regulated by means of a micrometer dial and a positive adjustable stop. The latter enables the cutter to be withdrawn from the screw thread and returned for cutting a thread groove of the same depth. The spindle of this machine is provided with a notched index ring and a pawl which holds the inner and outer spindle sections together, as described in connection with the machine illustrated in Fig. 4. When cutting a multiple thread the work is indexed by simply releasing the pawl and turning the inner spindle whatever fractional part of a revolution may be required.

Taft-Peirce Thread Milling Machine

A thread milling machine of the multiple-cutter type which completes a thread in practically one revolution of the work is shown in Fig. 11. This machine is manufactured by the Taft-Peirce Mfg. Co., Woonsocket, R. I. The cutter-spindle and work-spindle are driven by separate belts leading from the same countershaft. The work is held in some form of chuck or fixture at *A*, and the cutter, which is partly enclosed

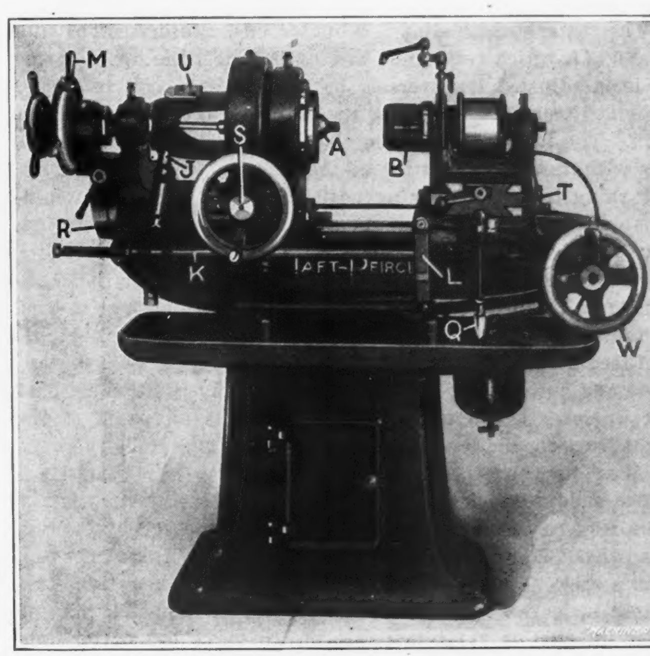

Fig. 11. Taft-Peirce Thread Milling Machine of Multiple-cutter Type

by a guard for the protection of the operator, is located at *B*. When a thread is being milled the cutter is set transversely for milling the thread to the proper depth, and the work-spindle then advances a distance equal to the pitch or lead of the thread as it turns one revolution plus a slight amount of over-travel. The work is held either in a self-centering chuck or a special fixture which may be fitted to the counterbore *A*, Fig. 12, on the front end of the work-spindle. This spindle is of the open yoke design and it is driven from a cone pulley at the rear of the machine, from which motion is transmitted through bevel gears to worm-shaft *E* and a worm to a worm-wheel on the work-spindle. This drive is controlled by the engagement of a sliding clutch operated by a rod *F* extending through the hollow worm-shaft. On the front end of this rod there is a knob *S*, Fig. 11, used for engaging or disengaging the clutch. The teeth in the worm-wheel are not of the usual concave or curved form, but extend in a straight path diagonally across the face of the worm-wheel, so that the work-spindle will be free to move longitudinally when milling a thread. This longitudinal movement is derived from a master nut *D* and a lead-screw *C*, Fig. 12. The lead-screw is made in two parts, and when assembled in the master nut there is a space between the two sections which provide a means for compensating for wear. The lead-screw and work-spindle rotate together and the master nut *D* and handwheel *M* are held stationary, when milling a thread, by lock-pin *N*, so that the work-

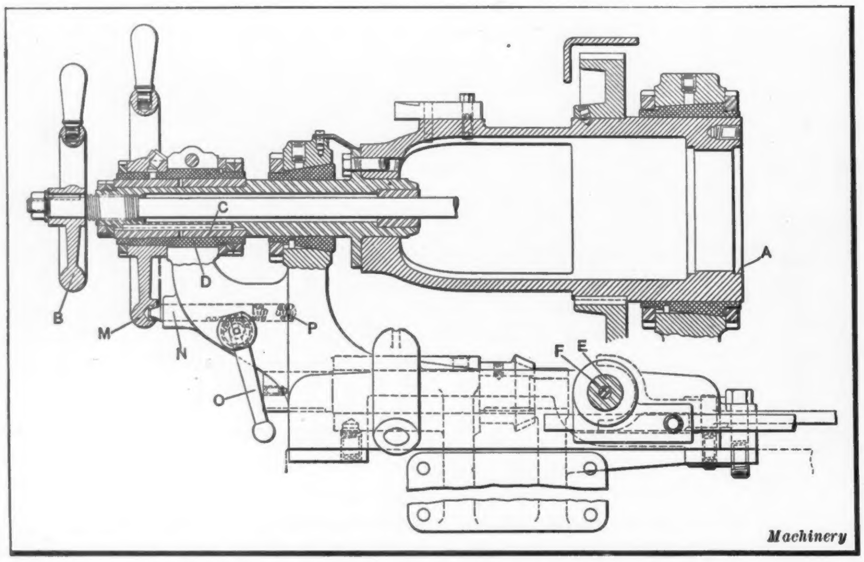

Fig. 12. Sectional View of Headstock of Machine shown in Fig. 11

spindle moves longitudinally. The pitch of the thread in the lead-screw and master nut must correspond with the pitch of the thread to be cut.

The cutter-spindle slide is mounted on an intermediate slide *T*, Fig. 11, which rests upon the lower slide. The upper cutter-slide is adjusted transversely by a screw. A positive stop is provided to insure returning the cutter-slide to the same position. The intermediate slide also has a transverse movement for withdrawing the cutter at the completion of a cut or for returning it to the working position. After the work-spindle completes one revolution, a cam *U* on the work-spindle engages a trip pin *J* and through a bell-crank mechanism operates the horizontal shaft *K* which releases the knock-off lever *L*. When this lever *L* is withdrawn, a spring throws the cutter-slide back so that the cutter is removed from the work; the work-spindle and feed motion are also stopped at the same time. The cutter-slide and cutter are returned to the working position by pulling up lever *Q*. After the cutter-slide has advanced to the right location, the lever *L* drops into place and holds the slide until another thread has been milled.

The saddle which rests on the bed and carries the cutter-slide may be adjusted longitudinally along the bed by turning handwheel *W*, the shaft of which carries a pinion meshing with a rack. For most external thread milling operations this saddle is locked in position and is seldom adjusted, but for most internal work it is necessary to move the cutter-slide along the bed for withdrawing the cutter from the work so that the piece can be removed from the chuck or holding fixture. A stop is provided on the bed against which the saddle is located in the operating position in order to maintain the same relation between the position of the cutter and the face of the fixture or work. When the parts to be threaded are inserted through the opening in the work-spindle at the rear of the front bearing for internal thread milling, it is not necessary to move the saddle when a part is completed.

Parts 3 1/4 inches in diameter by 10 inches long may be held in a spring chuck, and if a regular lathe chuck is used, it is possible to hold work up to 4 7/16 inches in diameter by approximately 18 inches long. When a lathe chuck is applied to this machine it is fitted to the counterbore *A*, Fig. 12, at the front end of the work-spindle. Special chucks or fixtures for holding flanges, etc., may be as large as 18 inches in diameter, which represents the full swinging capacity of the machine. Pneumatically operated chucks are recommended for use in this machine, as it is possible to increase the production from 20 to 50 per cent as compared with hand-operated chucks. The handwheel shown at *B* is used for operating chucks of the spring or collet type. This type of machine is especially designed for milling comparatively short internal or external threads located at or near the ends of parts. Fig. 13 illustrates a typical example of external work. The length of thread which can be milled depends, of course, upon the pitch of the thread and the kind of material that is to be cut.

Some examples of work milled on the Taft-Peirce machine are shown in Fig. 14. The internal threading operation on the small brass parts shown at *A* was done at the rate of 90 pieces per hour; the thread in this case is 1 3/16 inch diameter and 20 pitch. The internal threading operation on the part shown at *B* was done at the rate of 55 pieces per hour, the threads being 1 3/8 inch diameter and 6 pitch. The brass part illustrated at *C* has a thread 2 inches in diameter and 14 pitch, and was milled at the rate of 60 per hour The pressed aluminum piece shown at *D* has an external thread 1 3/8 inch in diameter and 6 pitch; the thread is the Whitworth form and these parts were milled at the rate of 70 per hour. The clutch housing shown at *E* has a 3-inch thread of 16 pitch, and 26 housings were milled per hour. The internal threading operation on the part shown at *F* was performed at the rate of 30 pieces per hour, the thread being 3 1/4 inches in diameter and 16 pitch; the external thread on this same part is 4 1/2 inches in diameter and 16 pitch, and was milled at the rate of 25 pieces per hour. The different rates of production referred to are not given as representing the maximum, but the output under normal conditions in regular manufacturing practice.

Lees-Bradner Multiple-cutter Type of Thread-Milling Machine

The Lees-Bradner special or "collet type" thread milling machine shown in Fig. 15 is the type having a multiple cutter and a lead-screw driven through change-gears selected with reference to the pitch of the thread to be milled. The work-spindle is driven through suitable gearing from a single constant-speed belt pulley at the rear, and the cutter-spindle is revolved by a belt operating on pulley *C*. The rotation of the work-spindle as well as the feeding movement of the cutter-slide may be started or stopped by operating hand-lever *D*, which serves to engage or disengage a friction clutch.

The cutter-spindle is carried by a slide *E* (see also the sectional view, Fig. 16), which, in turn, is mounted on an intermediate slide *N*, supported by a bottom slide or main saddle *J*, which rests upon the ways of the machine bed. The main saddle *J* may be adjusted along the bed by handwheel *K* for locating the cutter in the right lengthwise position relative to the work, and this saddle may be locked to the bed. The intermediate slide *N* connects with a short lead-screw *R*, Fig. 16. This lead-screw is driven through gearing by a splined shaft *S*, which is revolved by means of change-gears selected according to the pitch of thread to be milled. The upper slide which carries the cutter-spindle may be adjusted in a cross-wise direction by means of handwheel *F*, Fig. 15, to suit the diameter of the work and depth of thread to be milled. When the feed lever *M* is pulled over to the place marked "feed" on the quadrant, the cutter-slide *N* operates, assuming that lever *D*

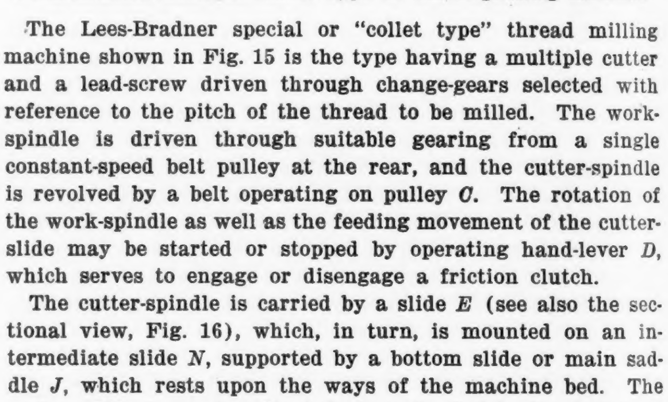

Fig. 13. Typical Example of Work done on Multiple-cutter Type of Machine

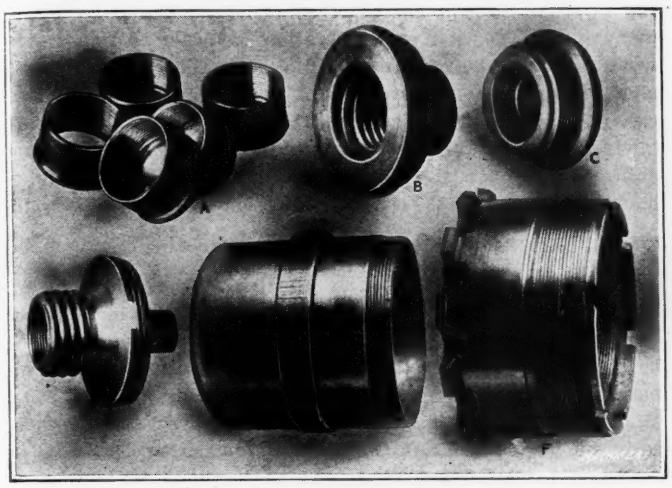

Fig. 14. Miscellaneous Examples of Thread Milling performed on Machine shown in Fig. 11

is in the right position. When lever *M* is thrown in the opposite direction as far as it will go, the work-spindle may be revolved with a rapid reverse motion.

Motion is transmitted to the intermediate cutter-slide by the splined shaft and lead-screw referred to, in order to avoid a reversal of the rotating parts each time a thread is milled and the resulting loss of time which would occur while waiting for any backlash or lost motion in the transmission to be taken up. When milling a thread, the intermediate and upper slides with the cutter-spindle are traversed along the bottom slide or main saddle *J* a distance equal to the pitch of the thread plus a slight amount of over-travel. This traversing movement is away from the chuck for internal milling and toward the chuck for some external milling operations. If ten threads to the inch were being milled, the traversing movement of the intermediate slide on the bottom slide would equal approximately 1/10 inch for each thread milling operation. As the intermediate slide has a total travel on the main saddle of about five inches, obviously threads could be milled on about fifty pieces before it would be necessary to return the intermediate slide to the starting point. The number of parts that could be milled before it becomes necessary to reverse the lead-screw and return the slide depends, of course, upon the pitch of the thread. When the intermediate slide has reached the limit of its travel, the clutch at *T*, through which the lead-screw *R* is driven, is disengaged by pin *V*. The operator then revolves the lead-screw in the opposite direction by means of handwheel *W*, or by means of the quick-return lever *M*, thus returning the slide to the other end of its travel preparatory to milling another lot of parts. Any movement of the main slide on the bed which may be necessary for inserting the work in the chuck or removing it does not necessitate disengaging the lead-screw clutch or reversing its driving mechanism.

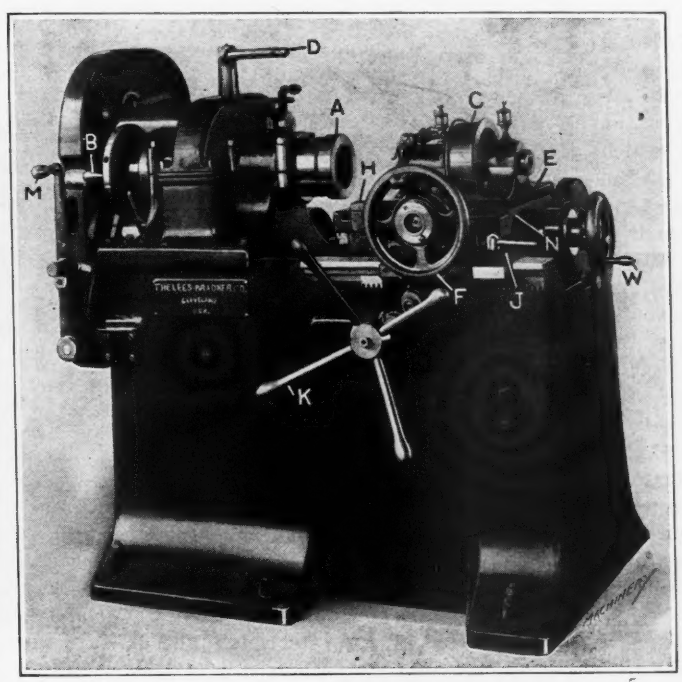

Fig. 15. Lees-Bradner Collet or Multiple-cutter Type of Thread Milling Machine

The crosswise position of the cutter is indicated by an adjustable micrometer dial reading to thousandths of an inch which is located just back of handwheel *F*. This dial is set at the zero position when the cutter just touches the part to be milled. The micrometer dial is then locked in position and the handwheel turned far enough to move cutter-slide *E* an amount depending upon the depth of the thread to be milled. When the cutter has been fed in to the right depth, a stop on the handwheel should be adjusted so that it is in contact with stop *H*. The latter may be adjusted by means of a binder screw operating in cutter-slide *E*, so that stop *H* will intercept the stop on the handwheel *F* when slide *E* is in position for milling a thread. The engagement between the two stops referred to is such that stop *H* moves far enough during one revolution of handwheel *F* to clear the stop on the wheel. When the cutter-slide is returned to the milling or working position, stop *H* will again engage the handwheel stop automatically and locate the cutter at whatever depth it was previously set to.

The collet chuck *A* in which the work is held is opened or closed by handwheel *B*. This collet chuck (see sectional view, Fig. 16) is an ingenious design so arranged that the collet is positively actuated both when opening and closing. This collet is made of machine steel and the jaws are casehardened, but the flexible part is left unhardened. When the collet is drawn back against the tapering seat *X* in the spindle, it grips the work, and when moved in the opposite direction one side of a V-shaped groove on the outer end engages another tapering seat in ring *Y*, thus positively forcing the collet jaws outward. The amount of this expansion is regulated by the distance the ring *Y* is screwed on or off the end of the spindle. With this arrangement it is unnecessary to have a spring temper in the flexible part back of the jaws. The detailed view, Fig. 17, shows one of these machines milling external threads on shell fuses.

Thomson Thread Milling Machine

The multiple-cutter type of thread milling machine shown in Fig. 18 is designed for milling threads on such parts as rifle barrels, rifle receivers, bronze primers, fuse bodies, the nose pieces for the smaller shells, automobile parts, watch cases, or whenever a short thread of a pitch not greater than 12 threads per inch (in steel) is required. When a thread is being milled, the work-spindle of the machine is advanced as it revolves by a short lead-screw which is mounted on the spindle and engages an adjustable nut *A*. The work-spindle and the cutter-spindle each have a separate driving belt. The large pulley *B* back of the headstock is for driving the work-spindle and transmits motion to it through worm-gearing. The belt pulley *C* drives the cutter-spindle by means of a silent chain. The cutter-spindle is carried by a vertical sliding head, which, in turn, is mounted on a carriage that can be moved along the horizontal ways of the machine bed by the handwheel *D*. The cutter is adjusted for the right depth of cut by means of handle *E* attached to the adjusting screw and equipped with a micrometer dial reading to thousandths of an inch. After the

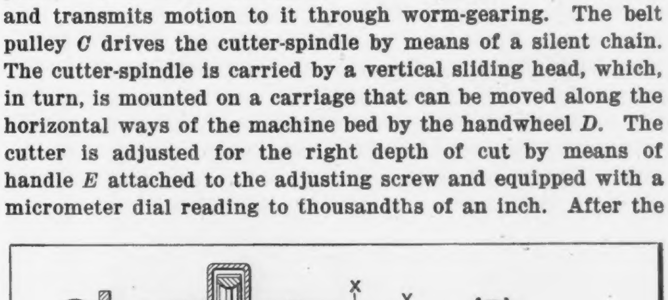

Fig. 16. Sectional View, showing Important Features of Machine illustrated in Fig. 15

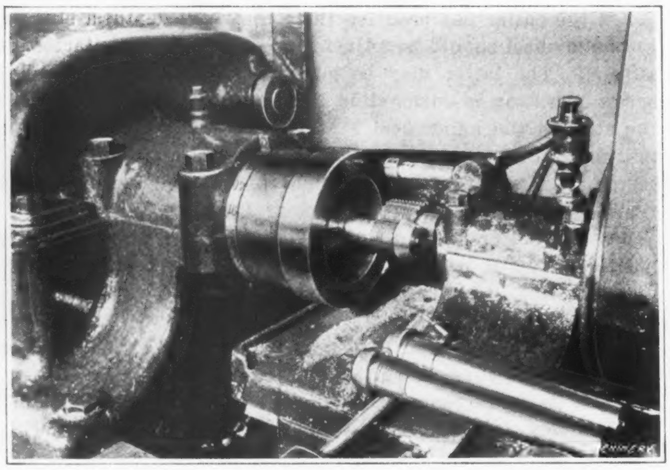

Fig. 17. External Thread Milling on Multiple-cutter Type of Machine

cutter is once set in the right position, it is advanced and withdrawn from the work by the action of a cam on the horizontal shaft F, which is turned by hand-lever G. One movement of this lever moves the cutter up to the cutting position and, at the same time, engages a clutch with the worm-wheel W, which revolves loosely on the work-spindle except when a thread is actually being milled. As the work-spindle revolves, it also advances at a rate depending upon the pitch of the lead-screw thread, which must correspond to the pitch of the thread to be milled. Attached to a drum on the work-spindle there is a wire cable H which connects with a spring drum located inside of the machine base. This cable is slowly wound upon the work-spindle drum as the spindle revolves, until a sleeve attached to cable H comes into contact with trip lever J. When this lever is raised, shaft F is released and is turned backward by the tension spring K, thus withdrawing the cutter from the work and stopping the spindle. The mechanism is so arranged that this tripping action occurs after the work has made a little over one revolution and the thread is completed. When milling internal threads, the cutter-slide is withdrawn by means of handwheel D after each operation, in order to remove the work from the chuck. An adjustable stop-rod L on the cutter-slide comes into engagement with stop M and serves to relocate the cutter after it has been withdrawn for removing work having internal threads. The cutter-slide is locked to the machine bed when a thread is being milled. This machine is made by the T. C. M. Mfg. Co., Harrison, N. J.

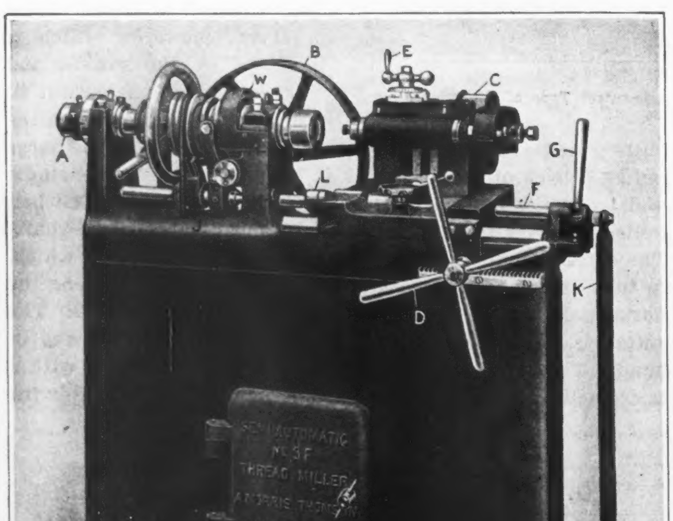

Fig. 18. Thomson Thread Milling Machine of Multiple-cutter Type

Smalley-General Thread Milling Machine

The thread milling machine illustrated in Fig. 19 is arranged especially for shell work, although it can be equipped for general thread milling by removing the special shell-holding chuck and attaching some other form of chuck. This machine (manufactured by the Smalley-General Co., Bay City, Mich.) has a multiple cutter for finishing a thread in practically one revolution, and the particular machine illustrated is equipped for milling threads in the bases of 9.2-inch high-explosive shells. The chuck for holding these shells is pneumatically operated, and by the use of liners the adapter and plugs for these shells may also be threaded in this machine. The cutter-spindle is mounted on a carriage which is traversed

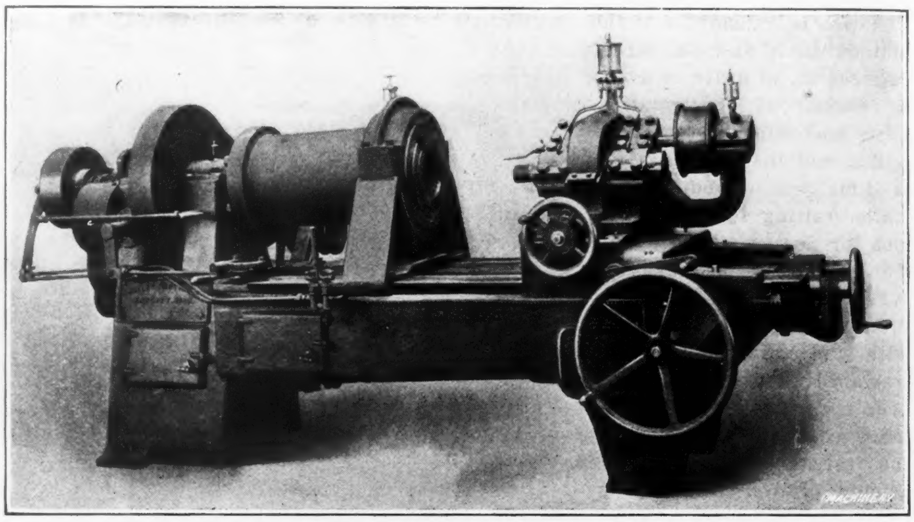

Fig. 19. Smalley-General Thread Milling Machine

along the bed by a gear-driven lead-screw when milling a thread. The carriage can also be traversed by turning the large handwheel seen at the front of the machine. The cutter-spindle and the work-spindle are driven independently by separate belts. The drive to the spindle is so arranged that the comparatively slow speed required for thread milling can be increased sufficiently for turning operations. In order to perform operations of this kind where a surface or shoulder must be absolutely true with a milled thread, the machine is equipped with a turning tool. This tool is located near the hob and it is used on the 9.2-inch shells referred to for finishing a recess at the end of the shell.

The tool is so located that the thread milling cutter can be used without moving the turning tool, or the latter can be used without removing the cutter. The normal feed for thread milling, which is about six inches per minute, is increased to twenty-five feet per minute for turning. The single belt pulley which drives the main spindle transmits motion to it through a worm-gear and spur-gear. The high speed for turning is obtained by driving direct through the spur-gearing, and the speed is reduced for thread milling by driving through the worm-gearing. This change of speed is obtained by shifting a lever located on the main head, which operates a clutch. This lever is held in either the high-speed, low-speed or neutral position by a notched quadrant. The gear on the main spindle which drives the train of change-gears is free to slide in or out of mesh for disengaging the lead-screw drive.

One of the special features of this machine is the method of engaging the lead-screw nut with the cutter-slide or carriage. On the lead-screw there is a nut which is attached rigidly to a wedge bar which moves along with the nut whenever the lead-screw is in motion. On the bottom of the cutter-slide

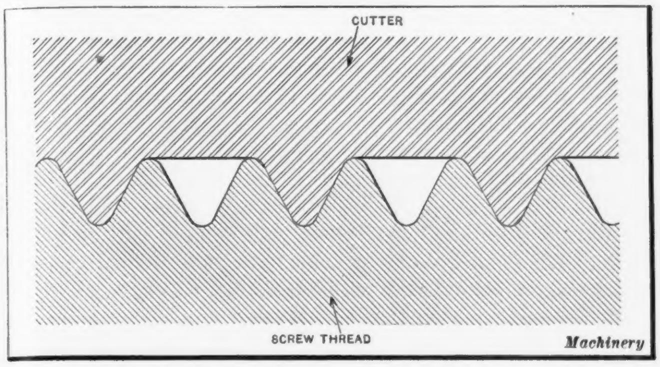

Fig. 21. Enlarged Sectional View, showing Multiple Cutter with Alternate Rows of Teeth removed for milling Comparatively Long Screw Threads

there are two wedge blocks. One block is fixed and the other is controlled by means of a lever which is located just above and back of the large handwheel for traversing the cutter-slide or carriage along the machine bed. These two wedge blocks engage grooves on each side of the wedge bar for transmitting motion from the lead-screw to the cutter-slide. The advantage claimed for this arrangement is that the operator does not have to wait for the lead-screw to engage a split nut. By introducing an extra idler gear in the train of change-gears, the lead-screw is made to rotate in the right direction for milling either right- or left-hand threads and the cutter-spindle moves outward in either case. The cutter-spindle of the machine illustrated is driven through herringbone gears from the belt-pulley shaft. Machines used for comparatively light work have the belt pulley mounted directly on the cutter-spindle.

To illustrate the method of using this machine, we shall assume that an internal thread is to be milled and a shoulder faced off true with the thread. After the work is chucked, the cutter-slide is traversed along the bed by the large handwheel until the hob or thread milling cutter is properly located in a lengthwise direction, the feed lever for engaging the lead-screw being released. The cutter is usually located by means of a depth gage or by moving it in against a shoulder which serves as a locating point. The main spindle should, of course, be revolving at the slow speed of five or six inches per minute and the cutter-spindle is also revolving. The cutter-slide is now connected to the lead-screw by means of the feed-lever and as soon as the cutter is fed into the work. The proper depth of cut is indicated by a micrometer dial on the cross-feed screw and the work should revolve until the cutter passes the point at which it started to cut to the full depth of the thread. When the thread is completed the cutter is withdrawn and the drive to the lead-screw is disengaged by means of a control lever provided for this purpose. The main spindle is now revolved at the higher speed for turning, and the turning tool is used for facing the shoulder true.

A larger machine designed along the same general lines as the one illustrated in Fig. 19 has been used for milling threads having a pitch of 1/4 inch, a length of 4 7/8 inches, and a diameter of 9 1/2 inches. Threads of this size were milled in nickel steel armor-piercing shells.

Reed-Prentice Thread Milling Machine

Fig. 20 shows a single-purpose thread milling machine designed especially for milling external threads on rifle barrels and the internal threads in rifle receivers. The machine, as illustrated, is arranged for the thread-milling operation on the receivers. The special work-holding fixture is designed to hold each receiver in the same position so that the thread will start at a predetermined point, thus making all the receivers interchangeable. When the machine is used for milling the external threads on rifle barrels, the receiver fixture shown in the illustration is removed and a special collet chuck is used which grips the barrel at the breech end close to the part that is to be threaded. The barrel extends through the hollow spindle of the machine and provision is made for accurately locating each barrel so that the threads start at a fixed point and are interchangeable with the receivers. The muzzle end of the barrel is supported by a special cam-action closer which holds the muzzle end concentric with the breech end. When a thread is being milled, the carriage upon which the cutter-spindle is mounted is traversed along the bed by a lead-screw, which is driven through change-gears. This lead-screw is engaged by a split nut, the arrangement being similar to an engine lathe. The bearing or bracket carrying the cutter-spindle is pivoted at one end, so that the cutters can be set in line with the angle of the thread, an adjustment of 5 degrees each side of the perpendicular being provided for. This machine is made by the Reed-Prentice Co., Worcester, Mass.

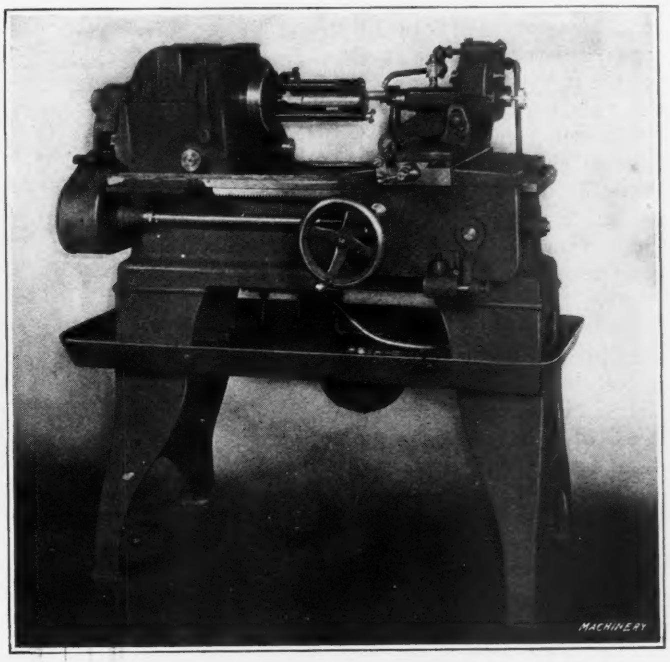

Fig. 20. Reed-Prentice Thread Milling Machine arranged for Internal Work

Classes of Work for which Thread Milling Machines are Adapted

Determining when the thread-milling process is superior to other thread-cutting methods may be very easy in some cases and very difficult in others. Each standard method of cutting threads, whether by milling, by means of taps and dies, or by using a single-point tool in the lathe, has its own advantages when applied under favorable conditions. The chief competitors of the thread milling machine are the engine lathe, dies for external threads, and taps for internal thread cutting. A thread milling machine may be used (1) because the pitch of the thread is too coarse for cutting with a die, (2) because the milling process is more efficient than using a single-point tool in a lathe, (3) in order to secure a thread which is smoother and more accurate as to lead than would be obtained with a tap or die, (4) or because the thread is so located relative to a shoulder or other surface that milling is superior to any other method if not the only practicable way of doing the work.

When making comparison between thread-cutting processes,

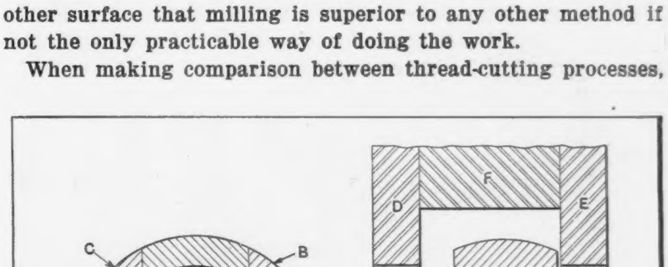

Fig. 22. Use of Duplex Cutter for milling Very Short Threads close to a Shoulder

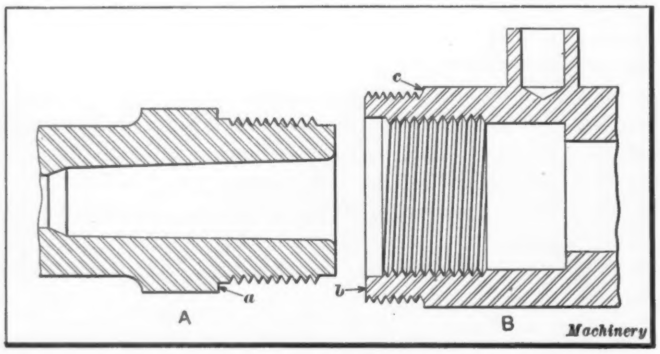

Fig. 23. Screw Threads on Rifle Barrel and Receiver which must qualify or register accurately with Other Surfaces

it is also essential to consider the relation that may exist between the thread cutting operation and other operations which may precede it. To illustrate this point, a lathe may be inferior to a thread milling machine for cutting a thread of a certain size and pitch, and yet the lathe may be preferable because cutting the thread is only one of a series of operations and by doing this work in the lathe the piece is finished at one setting and the thread is accurately located with reference to other machined surfaces. Similar conditions may exist in connection with work done in turret lathes or screw machines. For example, when a part requiring an internal thread is turned and bored in a turret lathe there is a decided advantage, in most cases, in finishing the part without removing it from the chuck and, ordinarily, some form of tap would be used, or a die in the case of external threads. In view of this close relationship between the method of cutting the thread and the work as a whole, it is apparent that any comparison between thread milling and other thread-cutting processes must be general and subject to modification. The classes of work for which the different thread-cutting methods are particularly adapted also merge into one another and there is no well-defined dividing line to serve as a guide.

Determining the relative merits of different thread-cutting processes is further complicated by the fact that a comparison between thread milling and the use of a lathe, die or tap, might be based either on the rate of production, accuracy of thread as to diameter and lead, smoothness of thread, or its location relative to other surfaces. The importance of these different features may, of course, vary considerably on different classes of work. It might be possible to obtain a much higher rate of production with a die than with a thread milling machine of the single-cutter type, but milling might be preferred in order to secure screw threads having a higher degree of accuracy as to lead than is usually obtained with a die.

Effect of Diameter, Pitch and Torsional Strain on Method of Cutting Thread

As the diameter and pitch of threads increase beyond the ordinary sizes, the use of dies for external work and taps for internal work becomes less practicable. If the screw is of large diameter, a die or tap must also be large and cumbersome, and the cost of these tools for cutting one size and pitch of thread may be prohibitive in view of the amount of work to be done. If a large number of duplicate threads are required, dies or taps may be used in preference to any other method even though the diameter is large, especially if the pitch of the thread is not so coarse as to cause distortion of the work as the result of torsional strain when cutting. Some parts such as sleeves, collar-nuts, etc., are difficult to hold firmly enough for tapping without distortion, but work of this kind can easily be handled on a thread milling machine. As a general rule the best method of cutting large screw threads of coarse pitch, multiple-threaded screws, or any form or size of thread requiring the removal of a relatively large amount of metal is by means of a thread milling machine equipped with a single cutter. The milling process is particularly desirable if the pitch of the thread and size of the thread groove is large in proportion to the diameter of the screw, because the metal removed by each cutting edge around the circumference of the cutter during one revolution is small and the screw being milled is not subjected to any great torsional strain. When a die is used for work of this kind, the accuracy of the screw may be seriously affected by the torsional strain or the twisting of the screw blank when cutting the thread. In some cases, duplicate screws large enough as to diameter and pitch to come well within the range of the single-cutter type of thread milling machine are cut by dies, because a greater production is obtained and the finish and accuracy of the threads are within the allowable limits.

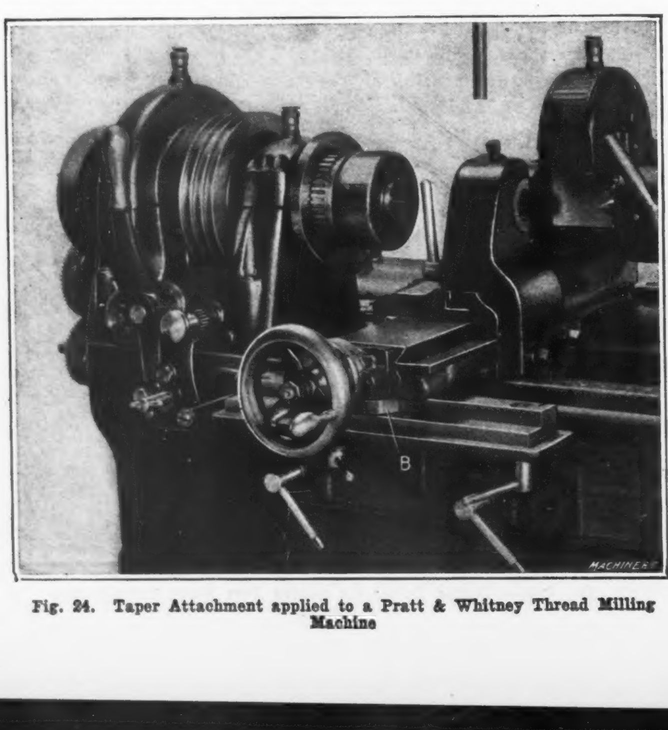

Fig. 24. Taper Attachment applied to a Pratt & Whitney Thread Milling Machine

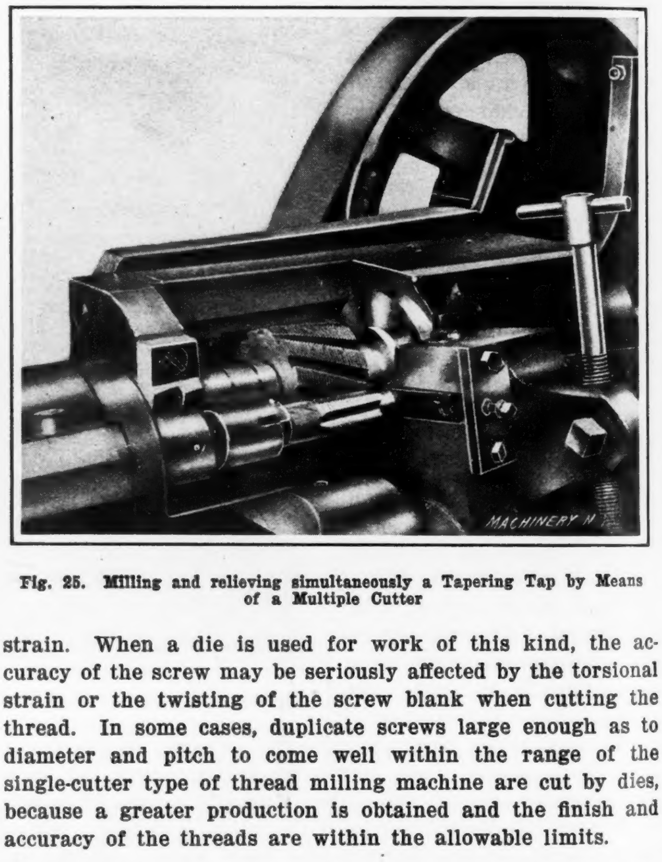

Fig. 25. Milling and relieving simultaneously a Tapering Tap by Means of a Multiple Cutter

Advantages of Thread Milling Machine as Compared with Lathe

The single-cutter type of thread milling machine is superior to the lathe for cutting threads on lead-screws, worms, etc., because it gives a higher rate of production due to the fact that the action of the milling cutter is continuous and a single cut usually finishes the thread complete. The thread milling machine has little if any advantage over the lathe in regard to accuracy of lead since both machines duplicate the controlling lead-screw. The heat generated when cutting the thread may, however, affect a screw cut in the lathe more than one that is milled. When milling a screw the blank revolves very slowly and the small amount of heat generated by the cutter is localized, so that it can readily be dissipated by using sufficient oil or cutting compound. As the single-point tool moves along more rapidly there is liable to be a greater expansion of the screw, which, when cold, may not be as accurate in regard to lead as a screw that has been milled. The rotating milling cutter is also more durable than a single-point tool and it can be used for cutting longer screw threads without sharpening and relocating the tool; moreover, the cutter is superior in maintaining a given diameter.

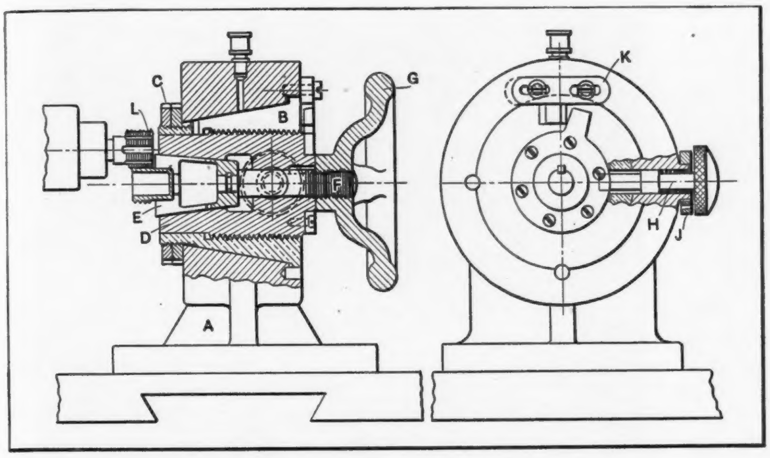

Fig. 26. Hand-operated Type of Thread Milling Fixture

The accuracy of a milled screw may depend upon several factors, such as the accuracy of the lead-screw on the machine, the condition of the cutter, the quality of the material of which the screw is made, the amount of oil or other cooling medium that is supplied, the accuracy of diameter of the screw blank, and the rate of feed. According to the Pratt & Whitney Co., lead-screws, when milled under favorable conditions, in most cases will not show an error of over 0.001 inch in any foot of their length. For accurate work of this kind, it is very important to use stock that is uniform in diameter and a good fit in the follow-rest bushing of the machine; in fact, screws that are to be milled should be ground if they are to run in a follow-rest bushing. Certain kinds of steel, which, because of their composition are difficult to cut smoothly with a stationary tool in a lathe are easily cut by milling.

Thread milling machines as a class have a further advantage, particularly as compared with the engine lathe, in that they are easier to operate and can be handled by unskilled labor. The fact that these machines are usually semi-automatic also makes it possible for one operator to attend to two or more machines on many classes of work. The number of machines that one man can operate to advantage depends partly upon the time required for milling the thread in one

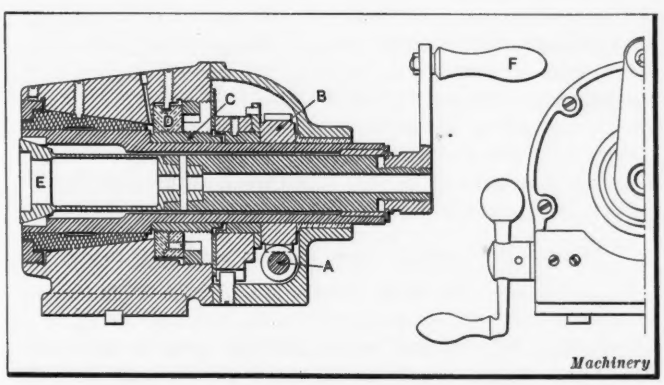

Fig. 27. Hand-operated Thread Milling Attachment having a Worm-gear Drive

machine. For instance, with a certain type of thread milling machine, if the actual milling time exceeds forty seconds, it is possible for an operator to run two or more machines.

General Application of the Multiple-cutter Type of Thread Milling Machine

As the multiple-cutter type of thread miller is applied to different classes of work than a machine having a single cutter, its relation to other thread-cutting methods is quite different. For work within its range, a multiple-cutter machine frequently comes into competition with dies and taps especially self-opening dies and collapsing taps. For some thread-cutting operations, it is generally conceded that the milling process is superior and more efficient than any other method. There is a decided difference of opinion, however, regarding the relative merits of these methods of cutting threads, particularly as applied to classes of work which are within the range of either the thread milling machine or a die, if the thread is external, and a tap if it is internal. The multiple-cutter type of thread milling machine has been used extensively in preference to collapsing taps when the thread must be cut close up to a shoulder or close to the bottom of a hole, as, for example, when cutting the threads, for the base plugs in shells. The sketches in Fig. 2 represent typical examples of external and internal work for which the multiple-cutter type of thread milling machine has proved very efficient, although its usefulness is not confined to shoulder work and "blind" holes. The milling cutter is used frequently in preference to a tap, because it produces a smoother thread, especially if the metal has soft stringy spots.

The diameter of the hole to be tapped and its length often have a decided effect on the preferable method of cutting threads, especially when comparing the multiple type of thread milling cutter with taps. The smaller the hole and the greater its length, the less practicable the milling process becomes. If the cutter is too large in proportion to the diameter of the hole to be threaded, the cutter does not clear itself, and if it is too long in proportion to the diameter, there is not enough rigidity for milling a straight and accurate thread, the cutter being deflected in a lateral direction. The limitations of the milling cutter as regards rigidity are subject to considerable variation and may be affected decidedly by the design of the machine, its condition, and whether the material being milled is hard and tough, or soft and easily cut.

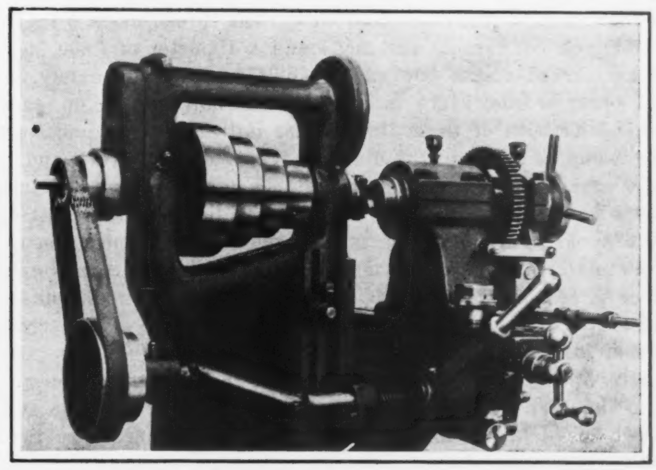

Fig. 28. Thread Milling Attachment for a Milling Machine

A simple method of increasing the maximum length of thread which can be milled with a multiple cutter is illustrated by the diagram Fig. 21. Every other row of cutter teeth is omitted, the distance between the teeth being equal to twice the pitch of the thread to be milled. By using a cutter of this kind, the lateral thrust or pressure is greatly re-

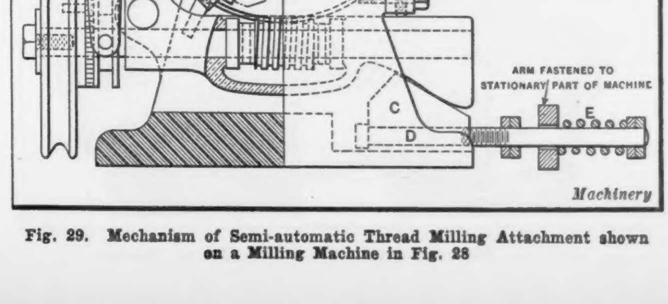

Fig. 29. Mechanism of Semi-automatic Thread Milling Attachment shown on a Milling Machine in Fig. 28

duced and a complete thread is milled by simply allowing the work to make two revolutions (plus the necessary over travel) instead of one revolution.

Milling Short Threads Close to a Shoulder

Very short threads, especially when close to a shoulder, are difficult if not impossible to cut by means of taps or dies, particularly when power is utilized for performing the operation. The throat of a die or the chamfer of a tap leaves that part of the thread adjacent to the shoulder unfinished, and if the throat or chamfer are omitted, all of the work is done by the first row of teeth which is objectionable. The milling process is very effective for this kind of work, even though only two or three threads are required, and the strength of the part will not permit cutting a recess or clearance space at the end of the thread.

An example of work illustrating the possibilities of the thread milling machine for milling very short threads close to a shoulder, is shown on an enlarged scale in Fig. 22. The thread milling operation to be described is on the central section *A* of a watch case. This central part requires a thread on both sides for receiving the bezel *B* and back of the case *C*, as indicated by the assembled view. The thread has a pitch of 1/54 inch (54 threads per inch) and a diameter of 1.800 inch. Each thread makes one and one-half turn approximately, or in other words, there is one and one-half thread on each side, and both of these threads are milled at the same time by a duplex cutter of the multiple type. The cutters *D* and *E* are separated by a collar or distance piece *F* which is just wide enough to allow for the necessary feeding movement of the work. This operation is performed on a Thomson semi-automatic thread milling machine similar to the type shown in Fig. 18. This machine is so arranged that the work-spindle is moved longitudinally by the direct action of a lead-screw when milling a thread. For this particular operation, the cutter-slide is adjusted so that one of the cutters just clears the shoulder. As the thread is milled, the work-spindle and work move in the direction indicated by the arrow, so that cutter *E* operates from the shoulder outward, whereas cutter *D* moves inward. This is a sharp V-thread having a 60-degree angle. The work is held in position on an expanding arbor *G* having shoulders for accurately locating it. These pieces were milled in this way at the rate of 160 per hour. The back *C* and bezel *B* of the case are also threaded on the same type of machine.

Screw Threads which must Qualify or Register with a Machined Surface

Thread milling is also especially applicable whenever screw threads on duplicate parts must "qualify" or maintain an exact relation with a fixed point or surface on the work. The external threads on rifle barrels and internal threads in receivers into which the barrels are screwed, are examples of work requiring threads accurately located, relative to a shoulder in the case of a barrel, and a finished face in the case of a receiver.

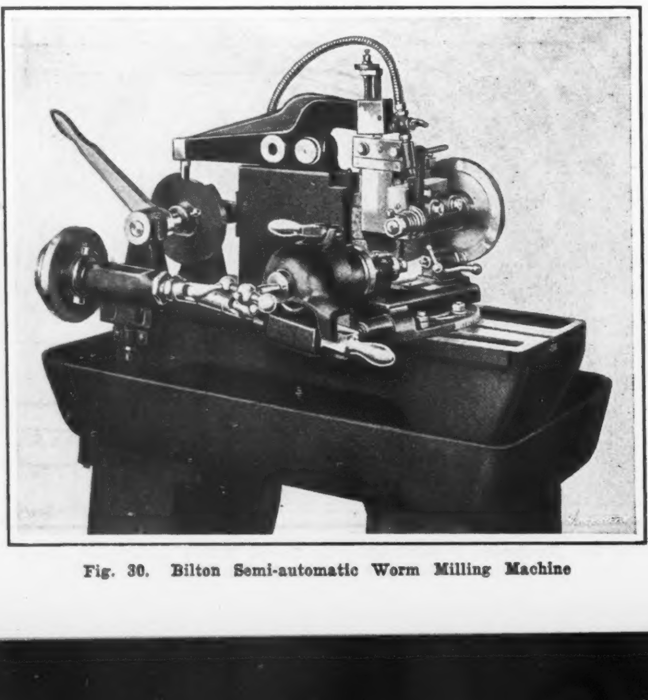

Fig. 30. Bilton Semi-automatic Worm Milling Machine

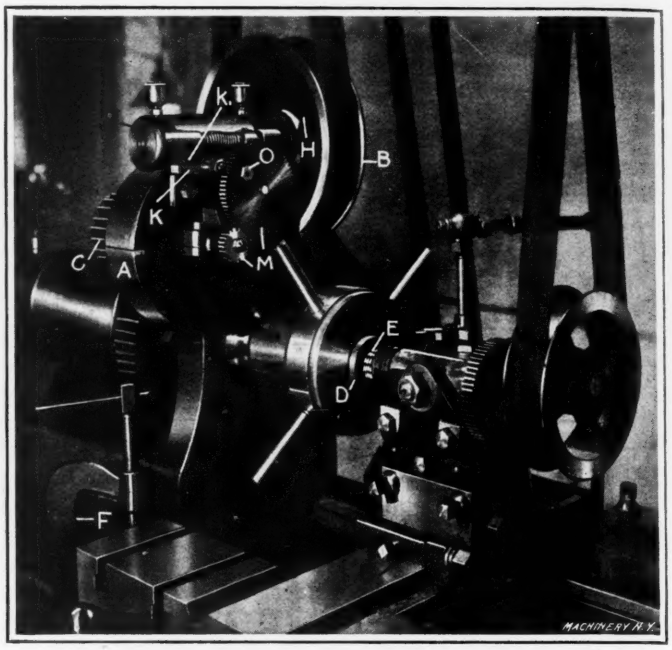

Fig. 31. Thread Milling Attachment Designed for Use on Engine Lathe

Examples of the kind of work that requires great accuracy in regard to the location of the threads are shown in Fig. 23. The thread on the rifle barrel, the end of which is shown at *A*, must not only be accurate as to diameter and pitch, but must qualify or register with the shoulder *a*. The internal thread in the receiver shown at *B* must also be accurately located with reference to the finished face *b*. When the rifle is assembled, the barrel screws into the receiver and if both threads did not register properly, the barrel would not be in the right position when screwed up against the shoulder. For instance, if the thread did not start at the right place and was, therefore, in a different location relative to the shoulder, the sight on the barrel (or the seat for an attached sight) when the latter is assembled, would not be in a vertical position or at the top.

The receiver shown at *B* has, in addition to the internal thread, an external thread which must qualify with a shoulder *c*. This particular receiver is for a Mauser rifle which has an outer tube or casing surrounding the barrel instead of the wooden grip such as is found on most military rifles. As this outer tube carries the sight, it is essential to have the thread accurately located with reference to the shoulder. For all work of this general nature, the thread milling machine is particularly adapted.

Cutter Interference when Milling Square Threads

It is difficult and often impossible to mill a satisfactory square thread, even when using a single cutter, owing to the interference between the cutter and the sides of the thread. The Acme thread, which is superior to the square thread, may be milled very easily with a single cutter, and is now used extensively for lead-screws and on many other parts which formerly had the square thread. The trouble due to cutter interference when milling square threads is more pronounced if the thread is a multiple form and, therefore, has a greater lead angle. The cutter should preferably be set to the helix angle of the thread at a point midway between the top and bottom of the thread groove. If the cutter is set to the angle at the bottom of the thread, the groove will be milled wider toward the top and have slightly curved sides. On the contrary, if the cutter is set to the angle at the top of the thread, the sides of the thread groove will be under-cut somewhat. A burr may also be formed by the cutter especially after the corners become dull. Trouble due to interference may sometimes be partly avoided by grinding the sides of the cutter slightly tapering or to an angle of from three to five degrees. Interference of the kind referred to does not occur when milling threads having angular sides because the cutting edges readily clear the angular sides after leaving the cutting position.

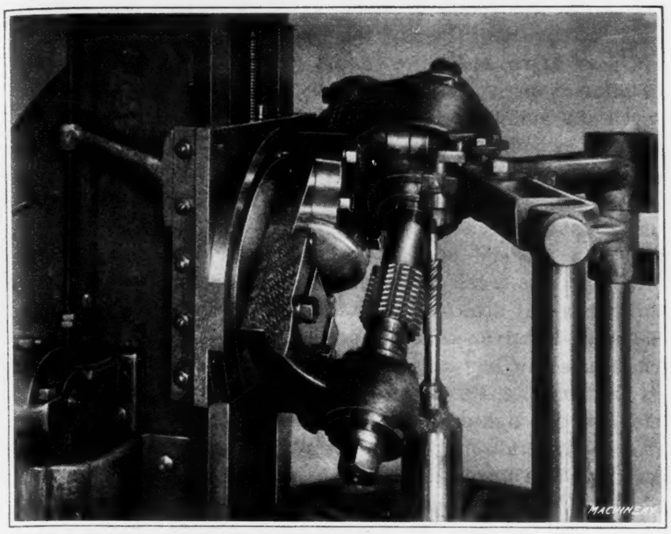

Fig. 32. Milling the Threads of a Multiple-threaded Screw by Means of a Hob and a Regular Gear-hobbing Machine

Milling Taper Threads

The milling of taper screw threads may be done on a single-cutter type of machine by traversing the cutter laterally as it feeds along in a lengthwise direction, the same as when using a taper attachment on an engine lathe. The taper attachment which is applied to some Pratt & Whitney thread milling machines is illustrated in Fig. 24. When the attachment is in use the cutter-slide is controlled by a guide-bar *A*. This guide-bar is inclined relative to the axis of the screw and it is engaged by a sliding block *B* on the front side and a roller on the rear side, which constrain the cutter to follow an angular or tapering path. This guide-bar is formed of two sections; by setting one of these sections parallel to the axis of the screw and the other to an angle, both tapering and straight screw threads can be milled. This feature is sometimes required when milling the threads on certain classes of taps having tapering ends followed by a straight section. The roller is held into contact with the rear side of the guide-bar by means of a spring which permits the use of a jointed guide-bar.

Taper threading on the thread milling machine can also be done when using the multiple type of cutter. One method of using a multiple cutter on tapering work is illustrated in Fig. 25, which shows a detailed view of a special machine used for cutting threads on taper taps. This particular machine is so arranged that it not only mills a tapering thread, but relieves it at the same time. The cutter is similar to the multiple type previously described in that it has annular rows of teeth which lie in planes perpendicular to the axis and are not helical like the teeth of a hob; the flutes are helical in this case instead of being straight or parallel to the axis. When a thread is being milled, the tap moves in a lengthwise direction as it revolves, at a rate depending on the pitch of the thread for which the tap is intended. The teeth of the tap are relieved as the result of an oscillating motion which is given to the multiple cutter. Each time the tap revolves, a complete cut is taken across every tooth so that two or three revolutions provide for both roughing and finishing cuts. The square end of the tap shank is finished before milling the thread so that this end can be inserted in a socket and used for driving the tap, while the other end is supported upon a conical center. This center is adjustable so that the tap can be located at the correct angle relative to the multiple cutter.

Speeds and Feeds for Thread Milling

The rate of production obtained with a thread milling machine may be affected greatly by the requirements as to accuracy and finish of the milled threads. The quality of the work depends considerably on the speed of the cutter and its relation to the feed. If the speed of the cutter is too slow for a given feed, the thread will not be finished as smoothly as it would be if a greater number of cutting edges passed the cutting position during a given feeding movement of the screw; therefore, to obtain a high rate of production and, at the same time, a smoothly finished screw thread, the cutter should revolve as rapidly as possible without dulling it excessively, and for this reason high-speed steel cutters are generally used for thread milling operations, although carbon steel cutters are preferable for milling such materials as aluminum, bronze and fiber as they will cut smoother threads. The surface speed of the screw blank may not exceed 2 or 3 inches per minute if the material is tough and especially if the thread is of rather coarse pitch; on the contrary, the surface speed may be increased to 6 or 8 inches per minute when the pitches are finer and the material cut more easily. Faster feeding movements are also used under favorable conditions.

The speed of the milling cutter usually varies from 100 to 125 feet per minute, with slower and faster speeds for some thread milling operations. The design of the machines and the general type may affect the speeds and feeds to some extent. The feeds and speeds recommended by the manufacturer of a single-cutter type of thread milling machine when equipped with a high-speed steel cutter are as follows: A surface speed for the cutter of about 100 feet per minute is a fair average speed for milling threads in machine steel, whereas for tool steel the speed should be reduced to about 70 feet per minute. When milling threads of moderate pitch such as 5 threads per inch and finer, the rate of feed is regulated somewhat by the quality of finish desired. When milling threads in machine steel and using a cutter 2¼ inches in diameter, a speed of 177 revolutions per minute is considered satisfactory, and a feed of about 4½ inches per minute provided there are 5 threads per inch or more; if the thread is coarser, say, 3 or 4 threads per inch, the feed should be reduced to 3 or 3½ inches per minute, and for 2 or 2½ threads per inch, to 2 or 2½ inches per minute. When milling tool steel, slower feeds are recommended and when milling brass much higher speeds and feeds may be employed. According to another manufacturer, a speed of about 125 feet per minute is approximately the maximum speed for tool-room work in steel, whereas for manufacturing operations, especially when milling soft steel, the speed may be considerably higher. When milling lead-screws or other accurate screws it is prerferable to feed rather slowly so that the stock may be thoroughly cooled, in order to avoid errors due to expansion and contraction. The cutter must also be kept sharp to prevent expansion or distortion of the stock due to the swaging action and the friction generated by the dull teeth. The condition of a cutter should be noted before beginning to mill a long screw so that it need not be changed until the milling operation is finished.

A manufacturer of a thread milling machine of the multiple-cutter type recommends a feed of 6 inches per minute and a cutting speed of 75 to 80 feet per minute when milling threads in soft steel. In fact the feed and speed mentioned have been used when milling 8 threads per inch or more in steel containing 0.55 per cent carbon. The feed for this work has also been increased to 9 inches per minute with satisfactory results. When milling threads of ¼ inch pitch in nickel

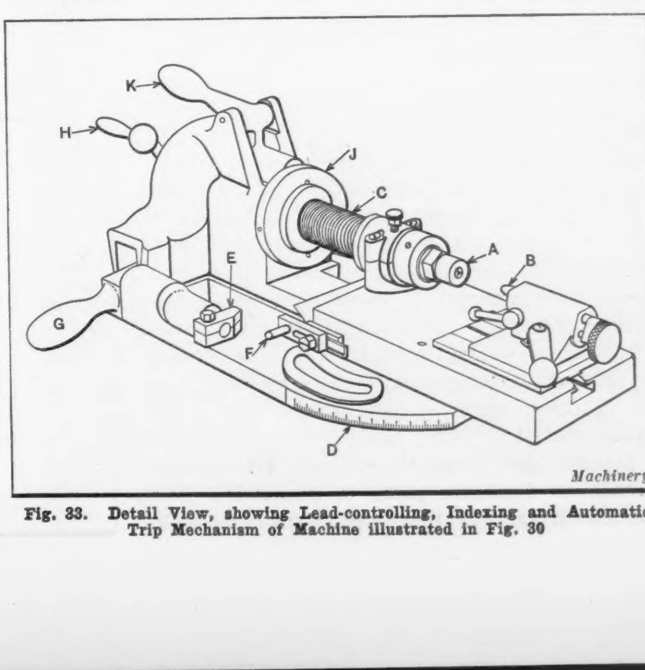

Fig. 33. Detail View, showing Lead-controlling, Indexing and Automatic Trip Mechanism of Machine illustrated in Fig. 30

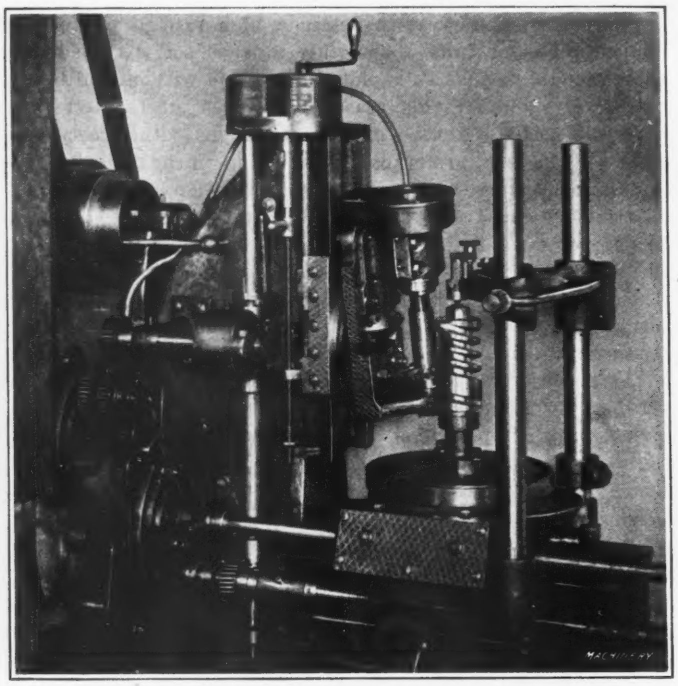

Fig. 34. Milling a Double Thread on a Farwell Gear-hobbing Machine equipped with a Single Milling Cutter

steel, a feed of 2 inches per minute and a cutting speed of about 50 feet per minute were utilized. While this is exceptionally heavy work for a multiple-cutter machine, the possibilities and limitations in any case may, of course, vary greatly, since the rigidity of a machine, its condition and the relation between the diameter of the cutter and its length are very important factors.

The speeds and feeds recommended by still another manufacturer of a multiple-cutter type of machine are given in the accompanying table which applies to a number of different materials, ranging from tool steel to brass. It is claimed that the speeds and feeds for a thread milling machine may be from 20 to 40 per cent faster than could be used when milling flat surfaces in connection with regular milling machine work. If the best results are to be obtained, cutters must be kept sharp as they will last longer, consume less power and produce more and better work. As form cutters are used the face of each cutting tooth should be ground radial to obtain the correct form of thread.

Thread Milling on Standard Milling Machines

Thread milling is frequently done on machines designed for general milling operations, such as the plain and universal milling machines of the columnm-and-knee type. There are two general methods of milling threads on ordinary milling machines. In the first place, the screw thread may be generated by using the spiral or dividing head the same as when performing any helical or spiral milling operation. The spiral head is geared to the lead-screw of the machine for traversing the table and work a distance per revolution corresponding to the lead or pitch, and the cutter is held and driven by some attachment such as a vertical spindle, universal or spiral milling attachment, the alignment of the cutter with the thread groove being obtained either by swiveling the work-table or by adjusting the cutter driving attachment. While this method is commonly employed for a variety of helical or spiral milling operations, its application to thread milling is largely confined to the milling of worms or relatively short screws of coarse pitch, especially when such work is not done on an extensive scale.

The second general method of milling threads on ordinary milling machines is by equipping the machine with a special attachment designed for this work exclusively. These attachments are usually designed for milling threads on duplicate parts in connection with manufacturing, and they are arranged to hold the work and rotate it along a helical path while a cutter held either directly in the machine spindle or on an ordinary arbor mills the thread groove. The simplest form of attachment consists principally of a base or frame which carries a spindle and a lead-screw connecting either with a hand crank or some combination of gearing for imparting a rotary motion to the spindle and work. A fixture intended for milling threads of fine pitch, especially in materials that are easily cut, may have a hand crank attached directly to the end of the work-spindle. With this arrangement, as the crank is turned, the lead-screw which passes through a nut attached to one of the fixture bearings, causes the work to advance at the proper rate for milling a thread. The lead-screw is a duplicate of the thread required, as far as its lead or pitch is concerned. While such a fixture may be used for the lighter classes of work, in general it is preferable to transmit motion to the work-spindle through worm-gearing. The worm-wheel may be carried by the work-spindle which is splined to permit endwise movement through the worm-wheel, whereas the hand crank is mounted on the end of the worm-shaft. Some of these hand-operated thread milling attachments are provided with indexing plates for milling multiple threads. Fixtures of the general type referred to may be used in conjunction with a single cutter or a multiple cutter may be employed for finishing a thread in one revolution of the work. If a multiple cutter is used, it is particularly desirable to have the work-spindle rotated through worm-gearing in order to obtain a more powerful turning movement.

Hand-operated Thread Milling Fixtures

The simple form of thread milling fixture shown in Fig. 26 is intended for use on an ordinary column-and-knee type milling machine. A multiple-cutter *L* is used for milling the thread and the work is held in a spring chuck or collet *E* which is opened or closed by turning hand-wheel *G*. The threaded part *D* serves as a lead-screw and passes through a tapering split bushing *B* which is held in position and adjusted by nuts *C*. The plunger *H* prevents the lead-screw from rotating when tightening or loosening the chuck. After the part to be milled is fastened in the chuck, plunger *H* is withdrawn and is held in the outward position by a small pin at *J*. The cutter is next fed in to the correct depth as determined by suitable stops and then the lead-screw *D* and work are advanced by turning handwheel *G* through one revolution. This turning movement is controlled by a sliding stop *K* which has elongated holes that permit it to move from one side of the vertical center line to the other, so that the lead-screw can make one complete turn. After a thread is milled, the cutter is withdrawn and the spindle rotated back to its starting position. The chuck is then loosened by handwheel *G* after engaging the locking plunger *H*. This attachment is intended for milling fine threads which are easily cut.

The hand-operated thread milling attachment illustrated in Fig 27, is equipped with worm-gearing for revolving the work spindle. The worm-wheel shaft *A* carries a crank at its outer end which is revolved to impart a feeding movement to the work. The worm-wheel on shaft *A* meshes with worm-wheel *B* which revolves the work-spindle. A threaded sleeve *C* at-

SPEEDS AND FEEDS FOR THREAD MILLING

Cast and Tool Steel	Machine Steel and Bronze	Wrought Iron	Cast Iron	Malleable Iron	Gun Metal	Aluminum	Brass
Cutting Speeds (Feet per Minute) for High-speed Steel Cutters							
70-100	135-155	140-160	145-165	155-175	170-190	180-220	200-240
Cutting Speeds (Feet per Minute) for Carbon Steel Cutters							
30-45	50-70	60-80	60-80	70-90	80-100	85-105	90-110
Feeding Movement of Work (Inches per Minute) for High-speed Steel Cutters							
5-8	6-9	8-10	10-15	10-15	15-20	20-30	20-30

Machinery

tached to the work-spindle passes through the nuts *D* and serves as a lead-screw. The parts to be threaded are held in the collet chuck *E* which is opened or closed by turning crank *F*. This crank is also used to return the work-spindle to the starting position after a thread is milled. This attachment is used in conjunction with a multiple cutter so that the thread is finished in practically one revolution. It is manufactured by the Hall Gas Engine Co., Inc., Bridesburg, Philadelphia, Pa.

Semi-automatic Thread Milling Attachment

A semi-automatic thread milling attachment which may be applied to milling machines having either a hand or power feed is illustrated in Fig. 28. This attachment was designed for performing internal and external thread milling operations in munitions plants although it may be used for other classes of work. The attachment is used in conjunction with a cutter of the multiple form which finishes a thread in practically one revolution. The feeding movement of the work spindle is derived from the countershaft which connects by means of a round belt with the pulley mounted at the left-hand end of the worm-spindle as seen in Fig. 29. This pulley transmits motion to the work-spindle through the worm and worm-wheel shown. When the worm is in engagement with the wheel it is held in position by a wedge-shaped part *C* connecting with rod *D* which passes through an arm which as the illustration indicates, is fastened to a stationary part of the machine. Interposed between this arm and a collar at the end of rod *D* there is a spring *E*. The purpose of this mechanism is to engage the worm automatically with the worm-wheel when the table of the machine is moved forward for bringing the work into contact with the milling cutter; on the contrary when the work is withdrawn the worm is released. This mechanism is so located and adjusted that the engagement of the worm and the rotation of the work begins before the cutter comes into contact with the part to be milled. Additional forward motion for cutting the thread to the proper depth is made possible by the compression of spring *E*. In operating this attachment the part to be threaded is placed in the collet chuck which is operated by the pilot wheel shown. This motion revolves the spindle until the stop-plate *A* which revolves loosely on the gear hub, comes against the stop *H*. The table is then run forward either by a hand-lever or the feed-screw handle, which automatically engages the worm and starts the work revolving, the rotary motion beginning just before the cutter comes into contact with the part to be threaded. When the work has made about one and one-tenth revolution the stop-plate *A* comes into position *F* and disengages the belt pulley driving clutch. As the screw thread is now milled, the table is withdrawn and the worm disengages from the worm-wheel. The finished part is then removed from the chuck and another piece substituted. Tightening the collet chuck again locates the stop mechanism in the starting position *G*. When milling internal threads it is also necessary to move the cross-slide of the machine. If a final finishing cut is required the attachment may be adjusted to automatically make two revolutions, one for roughing and the other for finishing. The thread is generated with this attachment by means of a lead-screw engaging a nut in the usual manner. This attachment is a development of the American Ammunition Co., Inc., Bordentown, N. J.

Thread Milling Attachments for Engine Lathes

Engine lathes equipped with special attachments have been used to some extent for cutting threads by the milling process especially in connection with shell work. The special mechanism for converting a lathe into a thread milling machine usually consists of an auxiliary slide which is mounted on the carriage and is arranged to carry the revolving cutter-spindle and, in addition, some form of drive for reducing the speed of the work-spindle so that the surface speed of the thread being milled will be only a few inches per minute. A thread milling attachment for the lathe designed by the New England Butt Co., Providence, R. I., is illustrated in Fig. 31, as applied to an ordinary sixteen-inch lathe. When using this attachment, the lathe is geared up the same as when cutting a thread with a single-point tool in the regular way. A multiple cutter is used so that the thread can be completed in practically one revolution of the work. The lathe spindle is driven from belt pulley *B* which transmits motion through a worm to a worm-wheel encased at *A*, and from the worm-wheel shaft through pinion *C* to the large gear on the machine spindle. This drive gives the spindle a backward motion so that the work revolves in a direction opposite to that of the cutter. The illustration shows an internal threading operation. The cutter is located longitudinally by moving the carriage against a stop at *F*. Another stop at *G* controls the crosswise position of the cutter and the depth to which the thread is milled. The work in this case is held in a collet form of chuck, and, after the cutter is located in a lengthwise direction, it is fed in to the full depth of the thread. Clutch *H* is then engaged by pulling forward knob *J* which starts the rotation of the work-spindle and the work. After the spindle has made about 1 1/10 revolution, a stop-pin at *O*, which is revolved through gearing *M*, releases stop *K* which disengages the driving clutch and the drive to the work-spindle. The thread is generated by the movement of the carriage along the bed the same as when cutting a thread in the regular way.

Bilton Worm Milling Machine

A machine designed especially for milling small worms or similar parts is shown in Fig. 30. This machine is semi-automatic in its operation, the machine stopping automatically after the worm thread is milled. The work is held in a collet chuck *A* (see detailed view, Fig. 33) and is additionally supported by a center *B* which may be either male or female. The spindle to which the chuck is attached is provided with a lead-screw or master worm *C* which is a duplicate as to lead or pitch of the thread to be milled. This lead-screw is revolved when milling a thread, through worm-gearing which connects by means of a telescopic shaft and universal joint with a belt pulley seen at the left of the machine in Fig. 30. The cutter-spindle is carried by a slide which is moved downward for locating the cutter in the proper position by the hand-lever which is also seen at the left of the illustration in Fig. 30. The required movement is imparted to the cutter-spindle slide by a cam on the hand lever shaft which operates a lever that extends forward to the cutter-slide. The work-holding fixture illustrated in Fig. 33 is set to the helix angle of the thread as indicated by graduations on the base at *D*. When a thread has been milled to the required length, the trip dog *E* comes into engagement with the adjustable stop *F* which releases lever *G* and allows the worm to drop out of mesh with the worm-wheel. The lead-screw and work-spindle are then returned to the starting point by means of handle *H*. This machine may be used for milling single, double, triple, and quadruple threads. The spindle is indexed for milling multiple threads with a single cutter, by means of index plate *J* which has holes engaged by a plunger or pin connecting with the

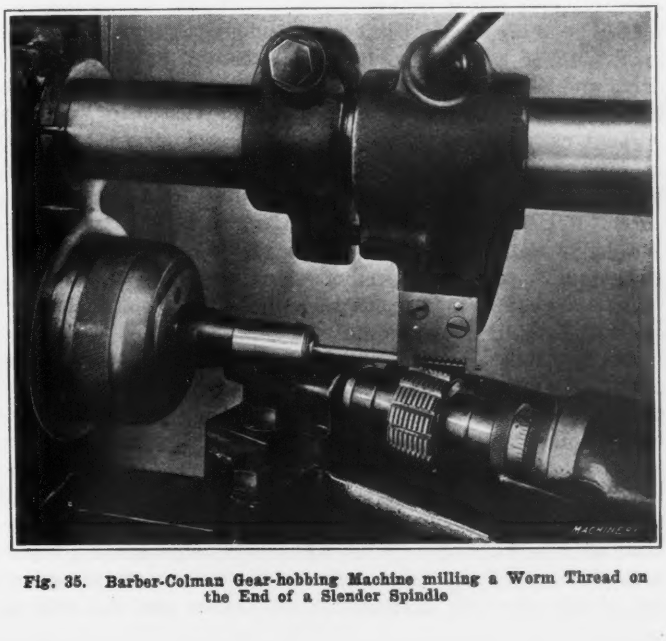

Fig. 35. Barber-Colman Gear-hobbing Machine milling a Worm Thread on the End of a Slender Spindle

operating lever *K*. For milling some double threads, a duplex cutter is used, so that both thread grooves are milled simultaneously and indexing is unnecessary. This machine has a capacity for work 1½ inch in diameter and 1½ inch long, but it has been used more extensively for milling the small worms required in phonographs, auto-horns, organs, etc., which usually vary from about ¼ to ⅝ inch in diameter.

Hobbing Method of Thread Milling

A hob is sometimes used in conjunction with a gear-hobbing machine for milling multiple screw threads. A hob used for this purpose has teeth which lie along a helical path, like a hob intended for cutting spur or helical gears, and it must be geared to revolve with the work at a definite speed ratio, the same as when hobbing a gear. The hobbing method is particularly efficient for cutting worms having several threads, because the hob finishes the different threads simultaneously. A hob having teeth of special form must be used for milling worms or other screw threads in order to generate threads having sides which are, at least, approximately straight. Fig. 32 shows a Farwell gear-hobbing machine milling a five-threaded worm. A single-threaded hob is used and the threads are cut much more rapidly than when an ordinary milling cutter is employed. The sides of the threads are not exactly straight but the curvature is slight. Multiple-threaded worms having four threads or more may often be milled to advantage with a single-threaded hob by the general method illustrated in Fig. 32, but if the worm has only a single thread or a double thread, it should preferably be milled by using a single milling cutter as illustrated in Fig. 34, instead of employing a hob. When a single cutter is used on this machine, the work-table of the machine is geared to the down feed so that a screw thread of the required lead will be milled but without reference to the speed of the cutter which may be regulated to suit the thread milling operation. When a screw thread is milled in this way, the gear-hobbing machine is practically a thread milling machine, so far as the principle of its operation is concerned.

An unusual and interesting application of a gear-hobbing machine to thread milling is illustrated in Fig. 35, which shows a No. 3 Barber-Colman machine cutting a worm thread on the end of a rather long and slender spindle. Owing to the flexibility of this spindle, a special form of work support was required. This consists of a plate supported by the overhanging arm and having two bearing surfaces which engage the screw thread at the ends, as the illustration shows.

* * *

THE SELECTIVE DRAFT

In the effort to form an army with the least possible confusion and hardship to the country, and especially to those industries on which the army's success most largely depends, all persons within the draft age have been arranged into five classes, which are as follows:

Class 1—Single man without dependent relatives. Married man, with or without children, or father of motherless children, who has habitually failed to support his family. Married man dependent on wife for support. Married man, with or without children, or father of motherless children; man not usefully engaged, family supported by income independent of his labor. Unskilled farm laborer. Unskilled industrial laborer. Registrant by or in respect of whom no deferred classification is claimed or made. Registrant who fails to submit questionnaire and in respect of whom no deferred classification is claimed or made. All registrants not included in any other division in this schedule.

Class 2—Married man with children or father of motherless children, where such wife or children or such motherless children are not mainly dependent on his labor for support for the reason that there are other reasonably certain sources of adequate support (excluding earnings or possible earnings from the labor of the wife) available, and that the removal of the registrant will not deprive such dependents of support. Married man without children, whose wife, although the registrant is engaged in a useful occupation, is not mainly dependent on his labor for support, for the reason that the wife is skilled in some special class of work which she is physically able to perform and in which she is employed, or in which there is an immediate opening for her under conditions that will enable her to support herself decently and without suffering or hardship. Necessary skilled farm laborer in necessary agricultural enterprise. Necessary skilled industrial laborer in necessary industrial enterprise.

Class 3—Man with dependent children (not his own), but toward whom he stands in relation of parent. Man with dependent aged or infirm parents. Man with dependent helpless brothers or sisters. County or municipal officer. Highly trained fireman or policeman, at least three years in service of municipality. Necessary customhouse clerk. Necessary employe of United States in transmission of the mails. Necessary artificer or workman in United States armory or arsenal. Necessary employe in service of United States. Necessary assistant, associate, or hired manager of necessary agricultural enterprise. Necessary highly specialized technical or mechanical expert of necessary industrial enterprise. Necessary assistant or associate manager of necessary industrial enterpr[illegible].

Class 4—Man whose wife or children are mainly dependent on his labor for support. Mariner actually employed in sea service of citizen or merchant in the United States. Necessary sole managing, controlling, or directing head of necessary agricultural enterprise. Necessary sole managing, controlling, or directing head of necessary industrial enterprise.

Class 5—Officers, legislative, executive, or judicial, of the United States or of State, Territory, or District of Columbia. Regular or duly ordained minister of religion. Student who on May 18, 1917, was preparing for ministry in recognized school. Persons in military or naval service of United States. Alien enemy. Resident alien (not an enemy) who claims exemption. Person totally and permanently physically or mentally unfit for military service. Person morally unfit to be a soldier of the United States. Licensed pilot actually employed in the pursuit of his vocation. Member of well-recognized religious sect or organization, organized and existing on May 18, 1917, whose then existing creed or principles forbid its members to participate in war in any form, and whose religious convictions are against war or participation therein.

The class into which a selective will be placed depends on his answers to the questions sent him. These questions have been arranged in twelve series and provide a full history of each man. Every question in the first series must be answered, as this series seeks to determine the place for which each man is best fitted. Question 3 asks for a list of all occupations at which a man has worked during the past ten years, and Question 10 asks for the length of time he has been engaged at any of a list of eighty-seven occupations, as well as any other occupation in which he may have become adept. In most of the other series only the first question need be answered in most cases.

* * *

The Bureau of Labor Statistics of the United States Department of Labor has recently made a report measuring accidents according to the time lost. A fatal injury is valued as a loss of thirty years of a man's working life, while total permanent disability is rated at thirty-five years. Other injuries are credited with losses in proportion to their probable effect upon the earning capacity. According to an investigation made in 194 plants, there were 13,647 accidents in 1912, resulting in 37 deaths, 411 permanent injuries, and 13,199 temporary disabilities. This is equivalent to an accident frequency rate of 118 per 1000 full time (300-day) workers, and a severity rate of 5.6 days per worker. These rates may be contrasted with a representative steel plant during the same year, for which the frequency rate was 154 and the severity rate of 14 days lost per worker, the accidents being only about one-third more frequent, but their severity was two and one-half times as great. The character of the machines built in the plants from which this information was taken varied greatly, from locomotives and ships to delicate electrical apparatus. In every case where the plants did not have a good safety organization the frequency rates were three or four times as high as those having a well developed system.

MEASUREMENT OF INTERNAL THREADS

BY WILLIAM S. ROWELL [1]

When a toolmaker has mating internal and external threaded parts to make, he uses a gage or gages if possible; but owing to the cost of gages and the time required for their production, this is not always possible. The measurement of external threaded work by the use of a ball-point or special type of thread micrometer is carried on to a limited extent, and any up-to-date mechanical handbook gives instructions for using wires and a standard micrometer for this purpose; but very little in this line is undertaken in the case of internal threads. For many years the writer has used an inside micrometer with ball-points to assist him in making and gaging internal threads and he highly recommends the use of such an instrument. Not only can it be used when no gage is obtainable, but it is also of use in connection with a gage. It tells what the gage cannot, namely, how much the gage lacks of entering when the thread is too small; and how much it is loose when the thread is too large.

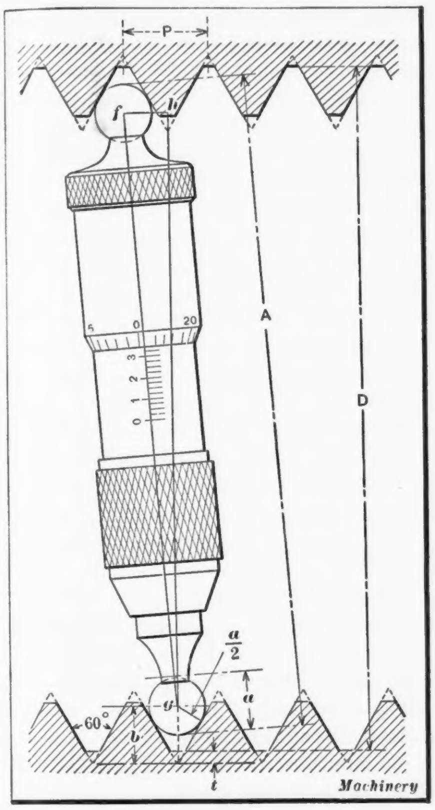

Fig. 1. Useful Type of Thread Micrometer

Inside micrometers are not yet made small enough to measure small internal threaded work, but large screws present the greater difficulty, and the toolmaker can usually adapt some inside micrometer for their measurement. Some enterprising tool supply firm should put on the market a line of attachable ball-points for external and internal thread micrometers, thereby doing both itself and the toolmaker a favor. As there is a singular lack of instruction in current mechanical works on measuring internal threads, the following may not be out of place. It may be said that the information given in handbooks on measuring external threads can be adapted to internal thread measurement, but the writer rarely finds a toolmaker who can use the information given in such books, because of the difficulty experienced in adapting these instructions to other conditions than those to which reference is made.

Referring to Fig. 1, if distance A cannot be read directly, it can be taken with an outside micrometer, after which the toolmaker proceeds to determine the outside diameter D of the thread. The following gives an expression for the different elements that enter into measurement D:

$$D = gh + 2b - 2t$$

Ball diameter a is known or easily obtained by the use of an outside micrometer and t is given by the following equation:

$$t = \frac{0.866P}{8}$$

Bearing in mind that the U. S. standard thread is a 60-degree angle, we can easily find the value of b from the following equation:

$$\frac{a}{2b} = \cos 60 \text{ degrees} = 0.5$$

Therefore, $a = b$

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By construction, $fh = \frac{P}{2}$

$$gh = \sqrt{\overline{gf}^2 - \overline{fh}^2}$$

We are now ready to proceed with the solution of an actual problem. Suppose that for a given thread the following data are available. A is measured with a micrometer and found to be 3.12 inches; a by measurement is 7/32 = 0.21875 inch.

$$fh = \frac{P}{2} = 0.1666 \text{ inch}$$

Using these data, we proceed as follows:

$$t = \frac{0.866P}{8} = \frac{0.866 \times 0.333}{8} = 0.0361 \text{ inch}$$

$gf = A - a = 3.12 - 0.21875 = 2.90125$ = hypotenuse of right-angle triangle fgh

$$gh = \sqrt{\overline{gf}^2 - \overline{fh}^2} = \sqrt{2.90125^2 - 0.1666^2}$$

$$= \sqrt{8.41725 - 0.02777} = \sqrt{8.38947} = 2.8964$$

$$b = a = 0.21875$$

$$D = gh + 2b - 2t = 2.8964 + 2 \times 0.21875 - 0.0722$$

$$= 3.2617 \text{ inches}$$

According to Mr. Converse, of the Pittsburg Model Engine Co., Homewood, Pa., comparisons of external and internal thread diameters (when measurements are taken with balls of the same diameter or with balls and wires of the same diameter) may be readily made. When internal and external threads are the same and the pitch P is standard or less, we have the following condition, illustrated in Fig. 2:

$$\text{External } A = \text{internal } A + 4a - \frac{2 \times 0.866}{P}$$

$$\text{Internal } A = \text{external } A - 4a + \frac{2 \times 0.866}{P}$$

$$\text{External } A - 3a = \text{internal } A + a - \frac{2 \times 0.866}{P}$$

If pitch P is more than one-eighth the diameter of the threaded work, or if the balls used are of maximum size, the varying angularity between internal A and external A would begin to show in the manner shown in a slightly exaggerated form in Fig. 2. Of course, it must always be borne in mind in fitting threaded parts that a certain amount of clearance must be allowed between internal and external threads, the amount of this clearance varying with the nature of the work, accuracy of thread-cutting tools and machines, and type of thread—whether single or multiple.

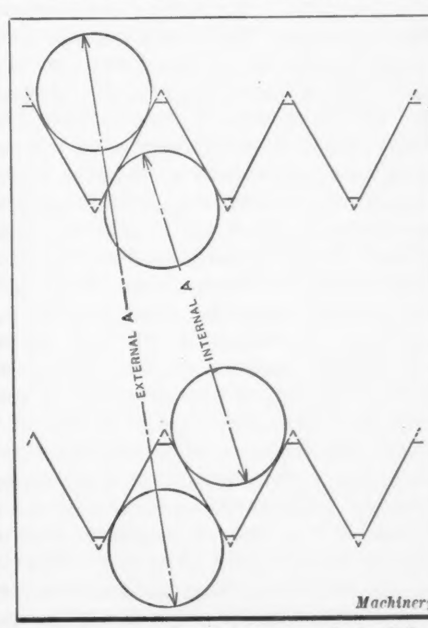

Fig. 2. Diagram explaining Formula for Relation between Measurements of External and Internal Threads

* * *

Over $163,000,000 is now invested in the dye industry in the United States. Thirteen of the plants are annually producing 49,100 tons of vegetable dyestuffs and extracts, while forty-six factories are producing 30,000 tons of artificial colors. Coal-tar dyes in a variety of colors suitable for leather, textiles, straw, paper, inks, stains, pigments, varnishes, waxes, feathers, furs, and many other purposes are regularly obtainable from domestic sources. During the year ending June 30, there were exported from this country $11,710,887 worth of dyes.

HELICAL SPRING COMPUTATIONS

CHARTS FOR DETERMINING DIMENSIONS AND PROPERTIES OF SPRINGS IN TENSION AND IN COMPRESSION

BY DONALD H. REEVES [1]

THE accompanying charts have been devised for the purpose of giving, in convenient form, a method of determining the various properties and dimensions of helical springs in tension and in compression without the necessity of figuring them out from formulas. There are instruments for this purpose, but, as a rule, these leave some of the factors to be computed; in addition, they are rather high-priced and are much less handy to carry than these simple printed charts, which are complete in themselves, except that a straightedge of some sort is required.

The chart shown in Fig. 1 may be used for any material at any stress and with any modulus of elasticity; the chart shown in Fig. 2 is to be used for steel only. It differs from the other in that provision is made for the varying safe stresses and moduli of elasticity that are correct for different sizes of wire. The two charts are made on exactly the same principles, have the same scales, and are used in exactly the same way.

Each chart consists of ten scales and a reference line, which are used in groups of three. Knowing the factors given on any two of the scales in a group, the value of the factor given on the third scale of the group is the point where a straightedge placed across the two known values intersects the third scale. In all cases the straightedge must cross the vertical line where the short calibration line, representing the value being used, meets it. On the size wire scale *K*, the size in inches will be found to the right of the vertical line, while to the left are several columns of numbers, which are the numbers of the gages most commonly used in measuring wire. In each case, except the very top row of figures, the line immediately under the gage number is the one to be used, and its intersection with the vertical line is the point through which the straightedge is to pass. This scale can also be used as a means of finding the size, in inches, of any gage wire. The scales used together in groups are as follows: Group 1—Rate per turn *A;* total rate *J;* number of effective turns *E*. Group 2—Rate per turn *A;* pitch diameter used with rate scale *F;* size wire *K*. Group 3—Rate per turn *A;* modulus of elasticity *B;* reference line. Group 4—Total rate *J;* load *C;* deflection *G*. Group 5—Load *C;* size wire *K;* pitch diameter used with load scale *H*. Group 6—Load *C;* maximum shearing stress *D;* reference line. Scales *B* and *D*—those giving the modulus of elasticity and the maximum shearing stress—are to be used only for the square-wire correction on the chart for steel springs.

Almost any information desired may be obtained by using, successively, different combinations of these groups. In some cases the information required can be obtained from one group. For instance, when the size wire and pitch diameter are given to find the safe load for a spring stressed to the extent for which the chart is calculated, a straight line through the size of wire on scale *K* and the pitch diameter on scale *H* will give the safe load on scale *C*. However, it is often necessary to use two or more groups, requiring two or more successive operations in order to get the desired results, owing to the fact that there are more than two known factors entering into the determination. Such is the case when the spring is given and it is desired to find the rate per inch, which is the load required to deflect the spring one inch. In this case there are three known factors, the size wire, the pitch diameter and the number of turns. As all of these influence the value of the unknown factor, two operations are necessary, assuming that round wire is used with the modulus of elasticity for which the chart is calculated. With this information, it is necessary to pass a straight line through the size wire on scale *K* and the pitch diameter on scale *F*, which will give the rate per turn on scale *A*. This result in itself is practically never used, but by passing a second line through it and the number of effective turns on scale *E*, the total rate of the spring, which is the value desired, can be found on scale *J*.

In using the charts, a straightedge that is transparent will be found most convenient. Lines should not be drawn, as these would soon make the chart unreadable. An easy way to locate the straightedge correctly is to find the position of one of the known factors on its scale and place some pointed instrument, such as a hard pencil or a pin, at this point. The straightedge may be swung around this, as on a pivot, until it passes through the value of the other known factor on its scale, locating the value of the unknown factor on the third scale. If this result is simply to be used in further calculations, as in the illustration just given, it is only necessary to locate this point with the pointed instrument and pivot the straightedge around it without reading its value.

The two groups using the reference line require a little different operation from the others. These groups are only used to find rates and loads for square wire or, on the chart shown in Fig. 1, when a material is used that has some other safe stress than 60,000, or some other modulus of elasticity than 12,000,000 or when a load is given to find the stress. The method of using the reference line will be fully described under the directions for finding these values.

The formulas used in constructing these scales are as follows:

$$\text{For round wire, } W = 0.3927\frac{Sd^3}{D};\quad F = 8\frac{PD^3}{Ed^4}$$

$$\text{For square wire, } W = 0.471\frac{Sd^3}{D};\quad F = 4.712\frac{PD^3}{Ed^4}$$

in which W = carrying capacity, in pounds;
S = greatest shearing stress, in pounds per square inch;
d = diameter of round wire or length of one side of square wire, in inches;
D = pitch diameter of coil, in inches;
F = deflection of one turn, in inches;
E = torsional modulus of elasticity;
P = load, in pounds.

For getting the flat wire factors on the chart for steel springs, only a comparison of the capacity and rate of the flat wire and of the round wire is wanted; so it is only necessary to get the formulas for torsional deflection and stress in round and flat wire, which are as follows:

$$\text{For round wire, } S = \frac{16W}{\pi d^3};\quad W = \frac{\theta\pi r^4 E}{4L}$$

$$\text{For flat wire, } S = \frac{6\sqrt{b^2+d^2}\,W}{bd^2+b^2d};\quad W = \frac{\theta bd(b^2+d^2)}{12L}$$

in which θ = angular deflection;
L = length of wire;
b = long side of flat wire;
d = diameter of round wire and short side of flat wire.

As most springs in general use are subjected to moderate vibration, the charts are made up for a factor of safety of 2. For brass and bronze wire, 30,000 pounds has been taken as a safe stress for ordinary service; where the service is to be at all severe, lower stresses should be used. For music wire a slightly greater stress can be used than for the same size ordinary spring wire of steel, and the modulus of elasticity will be correspondingly greater. The safe stress will range from 70,000 to 80,000, while the modulus of elasticity will be from 14,000,000 to 16,000,000. On the chart shown in Fig. 1, average values of 75,000 for stress and 15,000,000 for the modulus of elasticity have been marked for music wire; the steel chart will give results accurate enough for most work, however, except on very small sizes of music wire.

From the formulas given, it will be found that square wire will stand 1.2 times the load that round wire of the same size will stand and that the rate of the spring will be 1.7 times that of round wire. In a compression spring, the ends should always be ground square with the axis of the spring; this will

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make from one and one-half to two turns ineffective. A compression spring should have the ratio of length to pitch diameter as small as possible; if the ratio is more than 1:3, the spring should be guided to prevent bending.

Directions for Using Charts for Round Steel Wire

Given Rate per Inch of Spring, Number of Turns, and Pitch Diameter to Find Size of Wire—On the steel-spring chart, Fig. 2, pass a line through the total rate on scale *J* and the number of effective turns desired on scale *E;* this gives, on scale *A*, the rate per turn. Pass a line through this point on scale *A* and the pitch diameter on scale *F* to find, on scale *K*, the size of wire necessary. The nearest standard size of wire should be taken, but its strength should be found to insure its being strong enough for the purpose. Then pass a line through the size of wire on scale *K* and the pitch diameter on scale *F* to find, on scale *A*, the rate per turn; pass a line through this point and the total rate on scale *J* to find, on scale *E*, the exact number of turns necessary to give the desired rate. If the exact number of turns given must be used, the desired rate may be obtained by varying slightly the pitch diameter; but it is usually more important to keep the given pitch diameter than the given number of turns.

Given Number of Turns, Rate, and Size of Wire to Find Pitch Diameter—On the steel-spring chart, Fig. 2, pass a line through the total rate on scale *J* and the number of effective turns on scale *E;* this gives, on scale *A*, the rate per turn. Pass a line through this point on scale *A* and the size of wire on scale *K* to find, on scale *F*, the pitch diameter required.

Given Rate, Size of Wire, and Pitch Diameter to Find Number of Turns—On the steel-spring chart, Fig. 2, pass a line through the size of wire on scale *K* and the pitch diameter on scale *F;* this gives, on scale *A*, the rate per turn. Pass a line through this point on scale *A* and the total rate on scale *J* to obtain, on scale *E*, the number of effective turns.

Given Spring to Find Rate—Pass a line through the size of wire on scale *K* and the pitch diameter on scale *F;* this gives, on scale *A*, the rate per turn; pass a line through this point on scale *A* and the number of effective turns on scale *E* to find, on scale *J*, the rate of the spring.

Given Spring and Load to Find Deflection—First, find rate of spring; then pass a line through this point on scale *J*, and the load on scale *C;* the resultant deflection is the point where the line intersects scale *G*.

Given Spring to Find Maximum Safe Load—Pass a line through size of wire on scale *K* and pitch diameter on scale *H;* this gives the load on scale *C*. If the chart shown in Fig. 1 is used, the load found will be that which gives a stress of 60,000 pounds; but if the steel-spring chart, Fig. 2, is used, care must be taken to insure that the load found will give a factor of safety of 2. In all cases, scale *H* is to be used when the load, scale *C*, is to be found, and scale *F* is to be used when the rate is desired.

Given Spring to Find Maximum Safe Deflection—First, find rate of spring and its maximum safe load, then pass a line through points on scales *J* and *C* thus found; this gives, on scale *G*, the maximum safe deflection.

Given Load and Pitch Diameter of Spring to Find Size of Wire—Pass a line through the load on scale *C* and the pitch diameter on scale *H;* this gives, on scale *A*, the size of wire required. The nearest standard size of wire should be taken, but its strength should be determined to insure that it is strong enough.

Given Load and Size of Wire to Find Pitch Diameter of Spring—Pass a line through the load on scale *C* and the size of wire on scale *K;* this gives, on scale *H*, the pitch diameter.

Given Spring and Load to Find Stress in Wire—On the chart shown in Fig. 1, find the load for the spring, which is for a stress of 60,000 pounds per square inch. Pass a line through this point on scale *C* and a point marked "steel" on scale *D;* this gives a point on the reference line. Pass a line through this point on the reference line and the actual load on scale *C* gives, on scale *D*, the maximum shearing stress.

Scale *D* consists of several sets of values between 10,000 and 100,000. If the point on the *D* scale just found lies above the first 10,000 point above the "steel" point taken, add a digit to the number given on the scale; if the point is below the first 10,000 point below the "steel" point taken, subtract a digit from the number given on the scale for every 10,000 point passed. For example, if a spring has a stress of 60,000 pounds with a load of 600 pounds, if the load is 1200 pounds the stress point will be above the 10,000 point above the "steel" point used and the stress will therefore be 120,000 pounds and not 12,000. On the other hand, if the load is only 80 pounds, the stress point will be below the first 10,000 point below the "steel" point used and the stress will be 8000 pounds and not 80,000; if the load is only 8 pounds, the stress point will be two 10,000 points below and the stress will be 800 pounds.

Given Load and Deflection to Find Rate—Pass a line through the load on scale *C* and the deflection on scale *G;* this gives the rate of the spring on scale *J*.

Given Rate and Deflection to Find Load—Pass a line through the total rate on scale *J* and the deflection on scale *G;* this gives the load on scale *C*.

Given Load to Find Pitch Diameter and Size of Wire—The combinations of pitch diameter and size of wire that will carry a given load, with a factor of safety of 2, on the steel-spring chart, Fig. 2, will be any points on scales *H* and *K* that fall in a straight line through the load on scale *C*.

Special Directions

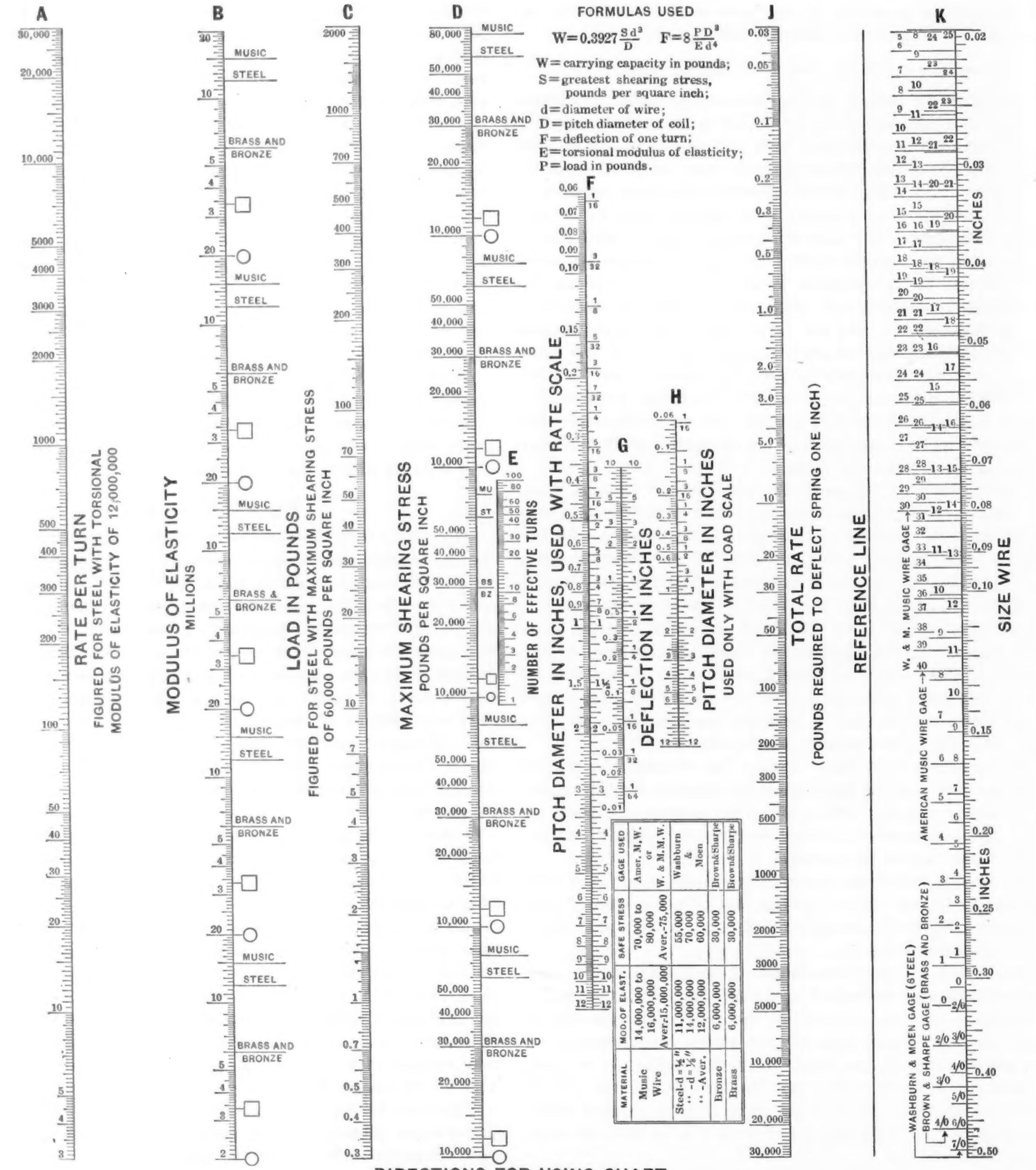
Using Charts for Square Wire—When square wire is used, the load causing a certain stress is 1.2 times the load that will produce the same stress in the same size of round wire; the rate per inch of a square-wire spring is 1.7 times the rate for an identical round-wire spring. Therefore, if the load that will give the same stress as for the same size round wire is desired, it is only necessary to find the load that an identical spring made of round wire will require and multiply by 1.2. This may be done by passing a line through the load for round wire on scale *C* and any circle on scale *D*, finding a point on the reference line. Pass a line through this point and the nearest square on scale *D* to find the desired load for square wire on scale *C*.

If the load is given for a spring made of square wire and other properties of the spring are to be found, it is necessary to find first the equivalent load for the same size round wire. This is done by passing a line through the given load on scale *C* and any square on scale *D*, finding a point on the reference line. Pass a line through this point and the nearest circle on scale *D* to find the equivalent load for round wire on scale *C*. Then proceed as for round wire. It is not necessary to get the equivalent value for round wire when the load and rate of a spring made of square wire are given to find the deflection, though care must be taken to make sure that the rate is given for square wire.

If the rate per inch of a spring made of square wire is given to find other properties of the spring, find the rate per turn on scale *A*, as directed for round wire, and divide this by 1.7 to find the equivalent rate of an identical spring made of round wire. To do this, pass a line through the rate per turn found for the square wire, on scale *A*, and any square on scale *B*, finding a point on the reference line. Pass a line through this point and the nearest circle on scale *B* to find the equivalent rate per turn for round wire on scale *A* and proceed as directed for round wire. If the rate of a spring made of square wire is desired, find the rate per turn on scale *A* for an identical spring made of round wire. Through this and any circle on scale *B* pass a line to find a point on the reference line. Pass a line through this point and the nearest square on scale *B*, to find the equivalent rate per turn on scale *A* for square wire. From this, the total rate of the spring may be found on scale *J* by passing a line through this point on scale *A* and the number of effective turns on scale *E*.

When using the circles and squares on scales *B* and *D*, the two that are nearest together must be used or an incorrect result will be obtained.

Using Chart Shown in Fig. 1 when other Stresses than 60,000 are Desired—If the spring is given to find the load that will produce some given stress, find on scale *C* the load that will produce a stress of 60,000 pounds. Passing a line through this point on scale *C* and steel point on scale *D*, find a point on the



FORMULAS USED

$$W = 0.3927\frac{Sd^3}{D} \qquad F = 8\frac{PD^3}{Ed^4}$$

W = carrying capacity in pounds;
S = greatest shearing stress, pounds per square inch;
d = diameter of wire;
D = pitch diameter of coil;
F = deflection of one turn;
E = torsional modulus of elasticity;
P = load in pounds.

MATERIAL	MOD. OF ELAST.	SAFE STRESS	GAGE USED
Music Wire	14,000,000 to 16,000,000 Aver.-15,000,000	70,000 to 80,000 Aver.-75,000	Amer. M.W. or W. & M.M.W.
Steel-d = ¼″ " -d = ⅛″ " -Aver.	11,000,000 14,000,000 12,000,000	55,000 70,000 60,000	Washburn & Moen
Bronze	6,000,000	30,000	Brown&Sharpe
Brass	6,000,000	30,000	Brown&Sharpe

DIRECTIONS FOR USING CHART

Place a straightedge through the known values on two scales to determine a value on a third scale.

Given Rate and Pitch Diameter to Find Size of Wire—Through rate on scale J and approximate number of effective turns on scale E, find rate per turn on scale A; through this point and pitch diameter on scale F, find point on scale K. Through nearest wire size, work back to find number of effective turns needed.

Given Rate, Number of Turns, and Size of Wire to Find Pitch Diameter—Through rate on scale J and number of effective turns on scale E, find rate per turn on scale A; through this point and size of wire on scale K, find pitch diameter on scale F.

Given Rate, Size of Wire, and Pitch Diameter to Find Number of Turns—Through size of wire on scale K and pitch diameter on scale F, find rate per turn on scale A; through this point and rate on scale J, find number of effective turns on scale E.

Given Spring to Find Rate—Through size of wire on scale K and pitch diameter on scale F, find rate per turn on scale A; through this point and number of effective turns on scale E, find total rate on scale J.

Given Spring to Find Deflection—Through total rate on scale J and load on scale C, find deflection on scale G.

Given Spring to Find Safe Load—Through size of wire on scale K and pitch diameter on scale H, find safe load on scale C.

Given Load to Find Pitch Diameter and Size of Wire—Any pitch diameter on scale H and size of wire on a straight line through load on scale C are correct.

Given Spring and Load to Find Stress—Find safe load on scale C at 60,000 pounds stress. Through this point and any 60,000 point on scale D, find a point on the reference line; through this point and the actual load on scale C, find stress on scale D.

Given Load and Deflection to Find Rate—Through load on scale C and deflection on scale G, find total rate on scale J.

Given Rate and Deflection to Find Load—Through rate on scale J and deflection on scale G, find load on scale C.

Square Wire—If rate of square wire is given to find other values, find rate per turn on scale A; through this and any square on scale B, find a point on reference line; through this point and nearest circle on scale B, find equivalent rate per turn for round wire on scale A. If load is given, use scales C and D in a similar manner.

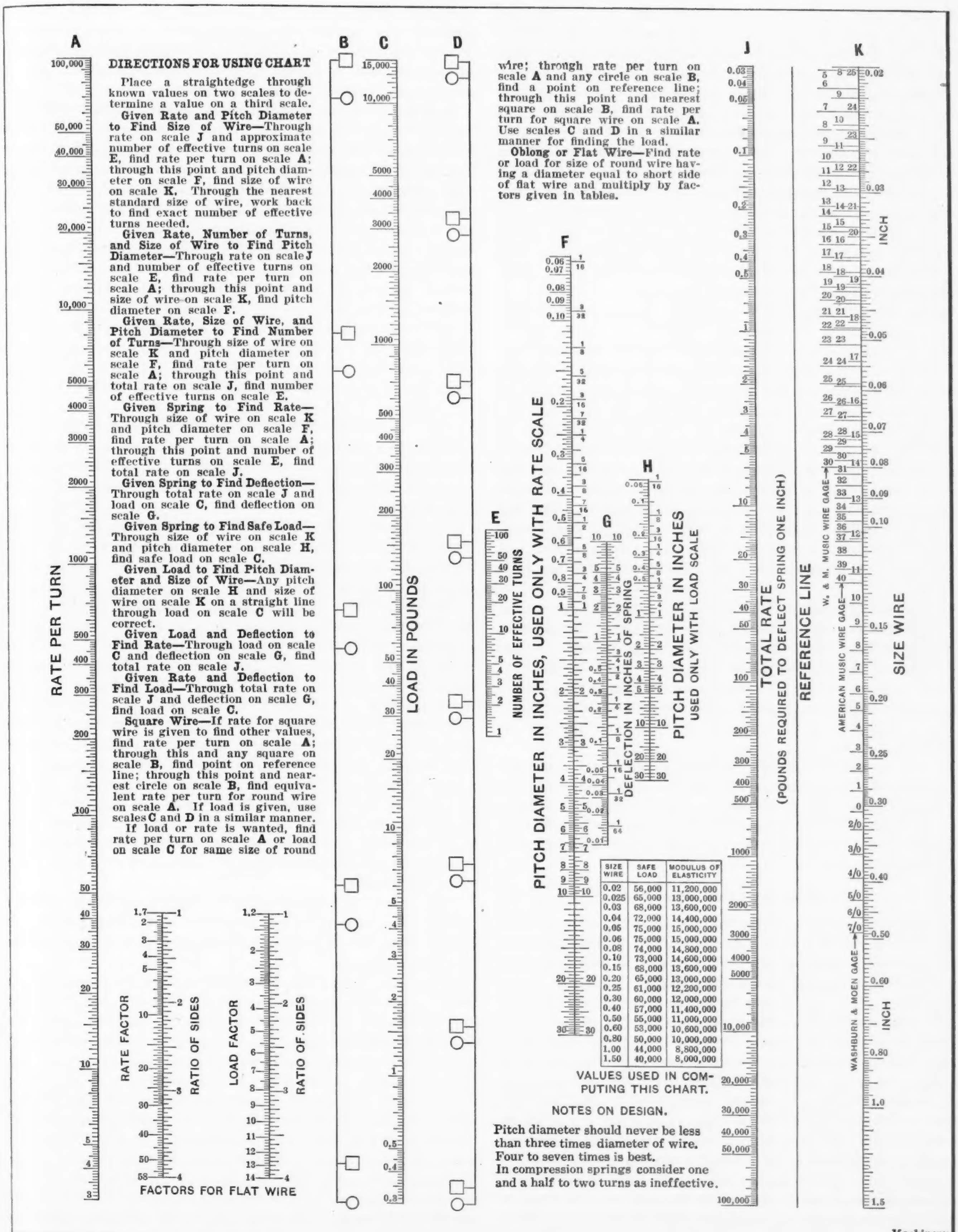
If load or rate is wanted, find rate per turn on scale A and load on scale C for same size of round wire; through rate per turn on scale A and circle on scale B, find a point on reference line; through this point and nearest square on scale B, find rate per turn for square wire on scale A. Use scales C and D in a similar manner for finding the load.

Materials Having Other Stresses or Elasticities than 60,000 and 12,000,000—Get results with these values and find equivalent results with desired values. If load and rate are given, find equivalent load and rate per turn at 60,000 and 12,000,000 and figure as usual. Find equivalent values as directed for square wire, using the desired and given values in the place of circle and square.

The pitch diameter of a spring should never be less than three times diameter of wire; from four to seven times is best. In compression springs, consider 1.5 to 2 turns ineffective.

Machinery

Fig. 1. Chart for computing Dimensions and Properties of Helical Springs



DIRECTIONS FOR USING CHART

Place a straightedge through known values on two scales to determine a value on a third scale.

Given Rate and Pitch Diameter to Find Size of Wire—Through rate on scale **J** and approximate number of effective turns on scale **E**, find rate per turn on scale **A**; through this point and pitch diameter on scale **F**, find size of wire on scale **K**. Through the nearest standard size of wire, work back to find exact number of effective turns needed.

Given Rate, Number of Turns, and Size of Wire to Find Pitch Diameter—Through rate on scale **J** and number of effective turns on scale **E**, find rate per turn on scale **A**; through this point and size of wire on scale **K**, find pitch diameter on scale **F**.

Given Rate, Size of Wire, and Pitch Diameter to Find Number of Turns—Through size of wire on scale **K** and pitch diameter on scale **F**, find rate per turn on scale **A**; through this point and total rate on scale **J**, find number of effective turns on scale **E**.

Given Spring to Find Rate—Through size of wire on scale **K** and pitch diameter on scale **F**, find rate per turn on scale **A**; through this point and number of effective turns on scale **E**, find total rate on scale **J**.

Given Spring to Find Deflection—Through total rate on scale **J** and load on scale **C**, find deflection on scale **G**.

Given Spring to Find Safe Load—Through size of wire on scale **K** and pitch diameter on scale **H**, find safe load on scale **C**.

Given Load to Find Pitch Diameter and Size of Wire—Any pitch diameter on scale **H** and size of wire on scale **K** on a straight line through load on scale **C** will be correct.

Given Load and Deflection to Find Rate—Through load on scale **C** and deflection on scale **G**, find total rate on scale **J**.

Given Rate and Deflection to Find Load—Through total rate on scale **J** and deflection on scale **G**, find load on scale **C**.

Square Wire—If rate for square wire is given to find other values, find rate per turn on scale **A**; through this and any square on scale **B**, find point on reference line; through this point and nearest circle on scale **B**, find equivalent rate per turn for round wire on scale **A**. If load is given, use scales **C** and **D** in a similar manner.

If load or rate is wanted, find rate per turn on scale **A** or load on scale **C** for same size of round wire; through rate per turn on scale **A** and any circle on scale **B**, find a point on reference line; through this point and nearest square on scale **B**, find rate per turn for square wire on scale **A**. Use scales **C** and **D** in a similar manner for finding the load.

Oblong or Flat Wire—Find rate or load for size of round wire having a diameter equal to short side of flat wire and multiply by factors given in tables.

SIZE WIRE	SAFE LOAD	MODULUS OF ELASTICITY
0.02	56,000	11,200,000
0.025	65,000	13,000,000
0.03	68,000	13,600,000
0.04	72,000	14,400,000
0.05	75,000	15,000,000
0.06	75,000	15,000,000
0.08	74,000	14,800,000
0.10	73,000	14,600,000
0.15	68,000	13,600,000
0.20	65,000	13,000,000
0.25	61,000	12,200,000
0.30	60,000	12,000,000
0.40	57,000	11,400,000
0.50	55,000	11,000,000
0.60	53,000	10,600,000
0.80	50,000	10,000,000
1.00	44,000	8,800,000
1.50	40,000	8,000,000

VALUES USED IN COMPUTING THIS CHART.

NOTES ON DESIGN.

Pitch diameter should never be less than three times diameter of wire. Four to seven times is best. In compression springs consider one and a half to two turns as ineffective.

Fig. 2. Chart for computing Dimensions and Properties of Steel Helical Springs

reference line; pass a line through this point and the desired stress on scale *D*, and find the corresponding load on scale *C*.

If the load is given and it is desired to find a spring that will have a certain stress when subjected to this load, pass a line through the given load on scale *C* and the given stress on scale *D*, finding a point on the reference line. Through this point and any "steel" point on scale *D* pass a line and find on scale *C* the load that will stress the same spring to 60,000 pounds and proceed as previously directed.

It will be noted that the stresses ordinarily used for brass, bronze and music wire are indicated on scale *D*. However, as the safe stress and modulus of elasticity for brass and bronze are just half of those given for steel, it is often easier to multiply or divide by 2, as the case may require, than to use the *D* and *B* scales and the reference line. If the desired stress is between 10,000 and 100,000, as is usually the case, it should be read on the *D* scale between the same consecutive 10,000's as the steel point used. If the desired stress is between 1000 and 10,000, add a digit and read between the two 10,000's immediately below the steel point used. If the desired stress is above 100,000, subtract one digit and read between the two 10,000's immediately above the steel point used.

Using Charts for Flat Wire—Either chart may be used for flat wire by using the flat-wire factors given on the steel-spring chart, Fig. 2. If a spring is made of flat wire, find the load or the rate, for an identical spring made of round wire having a diameter equal to the length of the short side of the flat wire. From the tables on the chart, find the rate and load factors for flat wire having the same ratio of sides as that being used and multiply the load for the round wire by this load factor and the rate for the round wire by this rate factor. The results will be the load and rate for the spring of flat wire. If the rate or load is given to find other properties of the spring, divide them by the rate factor or load factor, respectively; the result will be the rate or load for round wire having a diameter equal to the short side of the flat wire. With these values, proceed as for round wire.

Using Chart for Materials having other Modulus of Elasticity than 12,000,000—If the material used in a spring has a modulus of elasticity other than 12,000,000 the only effect on the use of the chart shown in Fig. 1 will be on the rate per inch of the spring and the deflection under a given load. In such a case if the spring is given to find the rate, find the rate per turn on scale *A*; this will be for a modulus of 12,000,000. To find the rate per turn that the spring will have with the given modulus of elasticity, pass a line through the rate per turn found on scale *A* and any steel point on scale *B*, finding a point on the reference line. Through this point and the given modulus of elasticity on scale *B*, find the corresponding rate per turn on scale *A*. A line through this point and the number of effective turns on scale *E* will give the total rate on *J*.

If the rate is given to find other properties of the spring, find the rate per turn on scale *A* by passing a line through the rate on scale *J* and the number of effective turns on scale *E*. Through this and the given modulus of elasticity on scale *B*, find a point on the reference line. Through this and a point marked steel on scale *B*, find the rate of the spring if it had a modulus of elasticity of 12,000,000 and proceed as previously directed.

It will be noted that the modulus of elasticity generally used for brass, bronze and music wire are indicated on scale *B* for convenience. If the modulus of elasticity that is being used is between 2,000,000 and 20,000,000, as will usually be the case, it should be read between the same two 20's as in the steel point used.

Examples for Round Steel Wire

Example 1—Given a spring of No. 14 Washburn & Moen gage steel wire, 0.08 inch in diameter, having 13 effective turns and a pitch diameter of 1/2 inch, to find the safe load, rate per inch, deflection and stress that will be caused by a load of 7 pounds, and the maximum deflection that will be allowable.

On the chart shown in Fig. 2, pass a line through 14 on the Washburn & Moen gage scale on scale *K* and the pitch diameter 1/2 on *H*. On scale *C*, the safe load will be found to be 30 pounds. From the table on the chart the stress used for 0.08-inch wire is 74,000 pounds per square inch. On the chart shown in Fig. 1 pass a line through 30 on scale *C* and 74,000 on scale *D* and find a point on the reference line. Through this point and the load to be imposed, 7 pounds, pass a line; the resultant stress, 17,500 pounds per square inch, is read where this line crosses scale *D*. Through the size wire on scale *K* on the chart shown in Fig. 2, and the pitch diameter on scale *F*, pass another line and find its point of intersection with the rate per turn on scale *A*. Through this point and the number of effective turns 13 on scale *E*, pass another line, finding the rate of the spring 47 pounds per inch, on scale *J*. A line passed through this and the load to be imposed, 7 pounds, on scale *C*, gives the deflection that will result 0.149 inch on scale *G*. Another line through the rate 47 on scale *J* and the safe load 30 pounds on scale *C* gives the maximum allowable deflection, on scale *G*, of 0.64 inch. Thus the five desired factors concerning this spring are found by the use of seven lines.

Example 2—Find the size of wire required for a spring with a pitch diameter of 2 inches and a load of 300 pounds.

On the chart shown in Fig. 2 pass a line through 300 on scale *C* and 2 on scale *H*, finding on scale *K* the size wire necessary to stand this load to be 0.29 inch. As this is not a standard size for steel wire, either No. 1 or No. 0 Washburn & Moen gage should be used. No. 1 will give a factor of safety of only 1.9, but as a rule, this would be permissible; No. 0, being larger, will of course be safer.

Example 3—A compression spring made of No. 0 wire and having a pitch diameter of 2 inches is compressed to 6 inches by a load of 300 pounds and to 6 5/8 inches by 248 pounds; find the free length of the spring and the number of turns. The difference between 300 and 248, or 52 pounds, is the load required to compress the spring the difference between 6 5/8 and 6 inches, or 5/8 inch. Using the chart in Fig. 2, a line through 52 on scale *C* and 5/8 on scale *G* shows, on scale *J*, that the rate per inch is 85 pounds. A line through this and 300 on scale *C* shows on *G* that the total deflection due to 300 pounds load is 3.6, so the free length of the spring will be $6 + 3.6 = 9.6$ inches. Passing a line through No. 0 on scale *K* and 2 on scale *F* gives the rate per turn on scale *A*. A line passed through this point and 85 on scale *J* gives, on scale *E*, the effective number of turns necessary, which is, in this case, 20.2 turns.

Examples for Round Bronze Wire

Example 4—Given a spring of No. 12 Brown & Sharpe gage bronze wire having 10 effective turns and a pitch diameter of 3/4 inch, to find the safe load, rate, and deflection with a load of 5 pounds.

Using the chart in Fig. 1, pass a line through No. 12 on the Brown & Sharpe gage scale on scale *K* and 3/4 on scale *F*; finding the rate per turn on scale *A* that the spring would have if made of wire having a modulus of elasticity of 12,000,000, which is the average for steel. Through this point and the point marked steel on *B*, find a point on the reference line. Through this point and a point marked bronze on scale *B*, find the rate per turn, on scale *A*, for the spring made of bronze wire. A line through this and 10 on scale *E* gives the rate of the spring on scale *J* to be 7.7 pounds per inch. A line through this and 5 on scale *C* gives the deflection, on scale *G*, for a load of 5 pounds to be 0.65 inch. A line through the size wire on scale *K* and 3/4 on scale *H* gives the load of 16.6 pounds on scale *C*, which will produce a stress of 60,000 pounds. Pass a line through this and a steel point on scale *D*, finding a point on the reference line. A line through this point and a bronze point on scale *D* gives the load of 8.2 pounds, on scale *C*, which will produce a stress of 30,000 pounds.

Example 5—A bronze spring is wanted that will stand a load of 10 pounds and have a rate of 20 pounds per inch with a pitch diameter of 1 inch; find the size of wire and number of turns necessary.

Using the chart in Fig. 1 through 10 on scale *C* and a bronze point on scale *D*, find a point on the reference line. Through this point and a steel point on scale *D*, find the equivalent load for a steel spring, which is 20 pounds. Through this and 1 on scale *H*, find the size of wire necessary, 0.096 inch. Taking the next higher standard Brown & Sharpe gage size, which is No. 10, 0.101 inch as the size to use, pass a line through this and 1 on scale *F*, finding the rate per turn for a spring of the same size of steel wire on scale *A*. Through this and a steel point on scale *B* find a point on the reference line. Through this and a bronze point find the rate per turn for the bronze spring. A line through this and the rate of the spring 20 on scale *J* gives the number of effective turns necessary, on scale *E*, which in this case is 3.9.

In this problem it is, of course, much easier to find the load that a steel spring would carry by multiplying the load of the bronze spring by 2 than by the method described. Also, in finding the number of turns necessary, the problem could have been worked through to conclusion for steel wire, which would give 7.8 effective turns necessary, and this is divided by 2 to get the number for the bronze spring.

Examples for Square and Flat Wire

Example 6—Given a spring made of 1/8-inch square steel wire, 1 inch pitch diameter, and 22 effective turns, to find the safe load and the rate per inch.

In Fig. 2 pass a line through 0.125, on scale *K* and 1 on

H, finding on scale *C* the load of 54,000 pounds, which would be the safe load for steel wire of round section. Pass a line through this and a circle on scale *D*, finding a point on the reference line. Through this and a square on scale *D* find the load of 65 pounds that the spring made of square wire will stand with the same stress. Pass a line through 0.125 on scale *K* and 1 on scale *F*, finding the rate per turn for round wire of that size. Through this and a circle on scale *B*, find a point on the reference line. Through this and a square on scale *B*, find the rate per turn on scale *A* for the square wire. A line through this and 22 on scale *E* shows, on scale *J*, that the rate of the spring is 35 pounds per inch.

In solving for square wire, the process is the same as in solving for some other material than steel, except that the circles and squares are used instead of the points marked steel and the desired values of stress and modulus of elasticity.

Example 7—Given a spring made of 1/8-inch by 3/8-inch flat steel wire, 1 inch pitch diameter, and 22 effective turns, to find the safe load and the rate.

Find the load for round wire as explained in Example 6, which is 54 pounds. The tables on the steel-spring chart, Fig. 2, give 8.1 as the load factor for wire having a ratio of sides of 3. Multiplying 54 by this gives, as the safe load for flat wire, 437.4 pounds. The rate per inch of a spring made of 1/8-inch round wire, in this case, would be 22.6 pounds. The flat-wire tables give the rate factor for wire having a ratio of sides of 3 as 25.8, so the rate of the flat-wire spring will be 25.8×22.6=583.1 pounds per inch.

* * *

HEAT-TREATMENT OF GRAY CAST IRON[1]

The rapid deterioration of cast-iron cylinder components, the liner, piston, and valve chambers, is a subject of vital importance to the internal combustion engine manufacturer. Frequently those components that are subjected to the direct influence of heat, crack and become utterly useless after a short life. This troublesome cracking is most pronounced in the cast-iron piston heads of Diesel engines.

The temperature that the center of the piston heads sustains during working is very high. In the ordinary four-cycle gas-engine, working at full load, the center of the head is at a dull red glow, approximately 650 to 700 degrees C. In the Diesel engine the flame, resulting from the spontaneous ignition of the charge, is driven directly against the center of the piston head so that the temperature of the inner surface in the center of the piston head (directly in line with the fuel admission valve) is at least 900 to 950 degrees C. The characteristic star cracks produced in Diesel engine piston heads after short periods of use, in many instances, can be traced to mechanical defects, such as bad design, defective cooling arrangements, etc., which tend under the influence of heat to set up unequal stresses in the material. As the strength of gray cast iron rapidly falls off with increasing temperatures, the influence of unequal stresses due to mechanical or other defects will be considerably more pronounced. The only change indicated by the analyses of cracked Diesel engine pistons is that the combined carbon is practically wholly converted into free or graphitic carbon. There appears to be no indication of oxidation of the carbon or silicon contents.

Tests on gray cast-iron bars show that at a temperature of 750 degrees C. practically all the combined carbon is rapidly converted into the free carbon form and that slow cooling is not a necessary factor in the dissociation of the pearlite. These tests also show that temperature between the limits of 750 and 900 degrees C. has little influence on the rate of decomposition, nor does there appear to be any influence exerted by the varying phosphorus content. Samples of gray cast iron heated to between 900 and 950 degrees C. for varying periods of time and quenched in water, showed that a portion of the free carbon had been reabsorbed. This reabsorption of free carbon is most important, both from a practical and a theoretical point of view.

A photomicrograph of a part of the piston that has been directly subjected to the influence of heat shows an enormous increase in the dentritic structure, and the whole of the matrix appears to be intersected by graphite plates. Near to the extreme upper edge of the piston, directly in contact with the flame, the extent of the dentritic structure is much less, and the matrix appears to be dotted with many more finely divided graphite plates; there also seems to be numerous small holes. It is probable that each individual bead or globule of cementite dissociates, depositing tiny flakes of graphitic carbon, and no doubt while some of these flakes appear to be drawn alongside the pre-existing plates of graphite, the internal pressure consequent upon the increase in volume of these newly formed free carbon plates tends to press these small flakes together, producing the numerous larger plates of free carbon. It is probable that the swelling of the graphite plates, or rather the replacement of these plates by holes, is in some manner connected with the reabsorption of the free carbon.

In all the heat-treated samples, the worm-like graphite forms appear to have swollen and become somewhat thicker. Undoubtedly this circumstance exerts a great influence on the weakening of the cast iron after subjection to heat and its consequent fracture. It is legitimate to conclude that as a result of these internal changes, which take place only in a localized portion of the piston top, the iron is rendered considerably weaker, and the slight volume changes that undoubtedly accompany these changes are responsible for a condition of internal strain. Under the conditions obtaining in the Diesel engine cylinder such a state of affairs will rapidly lead to fracture.

It has been found, as a result of long experience, that the ultimate cracking of Diesel engine piston tops, apart from those cases of mechanically defective pistons, can as a general rule be traced to the phosphorus content of the cast iron. By reducing the phosphorus content of the cast iron to the lowest possible limits, the life of the pistons may be considerably prolonged and the cracking practically eliminated.

[1]Abstract of a paper by J. E. Hurst, read before the Iron and Steel Institute of Great Britain, September, 1917.

* * *

THE LIBERTY MOTOR

When the Congress declared that a state of war existed between the United States and Germany, there was immediate general recognition of the importance of the airplane, and steps were taken to build a large number for the Army and Navy. The Liberty motor was the outcome of the effort to secure a composite design in which the best ideas of the motor builders of the United States were incorporated. Its advent was announced with a flourish of trumpets, but no details of the mechanical design were furnished for publication. Now we are informed that the Liberty motor is not quite as near perfection as at first believed, but is considered suitable only for scout duty and other comparatively minor air work. Thousands of dollars have been expended in the effort to build the Liberty motor with the utmost possible speed, and the discovery that it is not the equal of the best European motors comes as a disagreeable shock to the American people.

This unhappy development is one of the logical outcomes of secrecy and censorship. Had the design of the Liberty motor been published in the technical journals the government officials would have had the benefit of the constructive and destructive criticism of hundreds of engineers throughout the country. The effect of these criticisms that would have been leveled at the design could not have been anything else but beneficial. One important factor would doubtless have been better taken care of than it is, and that is the design of the motor as regards manufacture. It has been found by tool engineers having to solve the problem of tooling for rapid and efficient manufacture that in many cases the design could be modified with no resulting injury but with great improvement in the speed and ease of machining.

Secrecy is a firmly established war policy, but, so far as we can judge, it serves chiefly one purpose, and that is to keep the common people of the country in ignorance of conditions. The German military authorities doubtless know practically everything of military importance transpiring in this country. Their agents and spies are not dependent upon the daily and technical press as sources of information.

SCREW MACHINE TOOL EQUIPMENT—3

TOOL EQUIPMENT AND ATTACHMENTS FOR THE GRIDLEY MULTIPLE-SPINDLE AUTOMATIC SCREW MACHINE

BY DOUGLAS T. HAMILTON[1]

FIG. 28 shows the National Acme self-opening or automatic die-head, which can be applied to the Gridley automatics in the manner illustrated in Fig. 25, which appeared in the December number of MACHINERY. *A* shows the die-head closed and assembled, whereas *B* and *C*, respectively, show the die-head in detail open and closed. The chasers, as shown in Fig. 29, are arranged to slide in slots in the body, and are held in place by plates, to which they are fastened by screws, the plates fitting in the T-slots in the body. These chasers are closed by the action of the cam ring, the body being pulled back into the hood, thus bringing the chasers into contact with the bearing arms of the cam ring. Variations in diameter of the threaded part are secured by means of an adjusting screw operating on the principle of a micrometer and located in the side of the head.

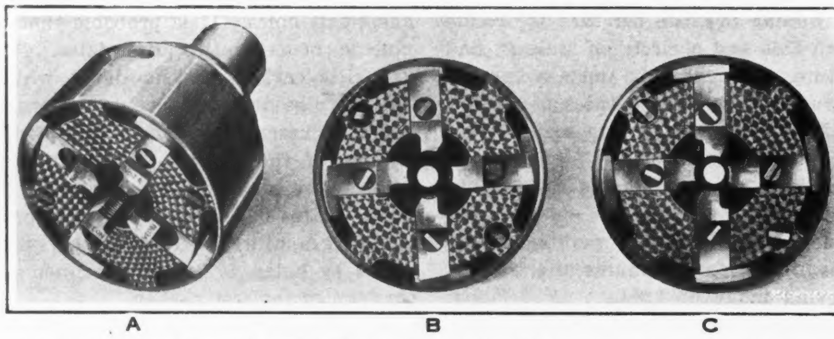


Fig. 28. National-Acme Automatic Die used on Gridley Automatics, shown Assembled and in Open and Closed Positions

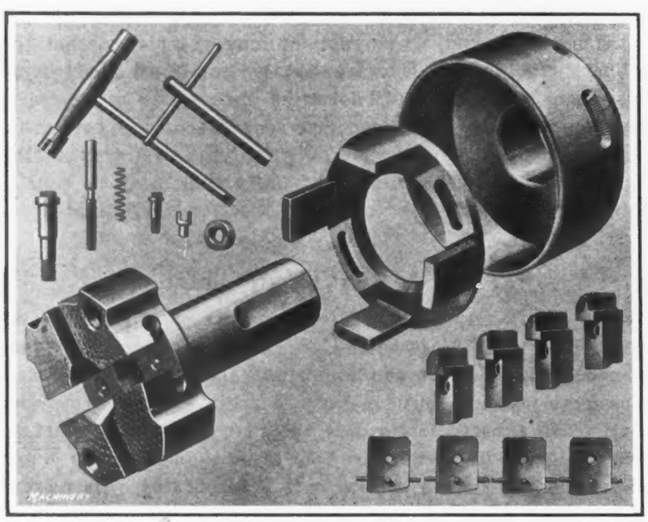


Fig. 29. Die-head shown in Fig. 28, dismantled to show Construction

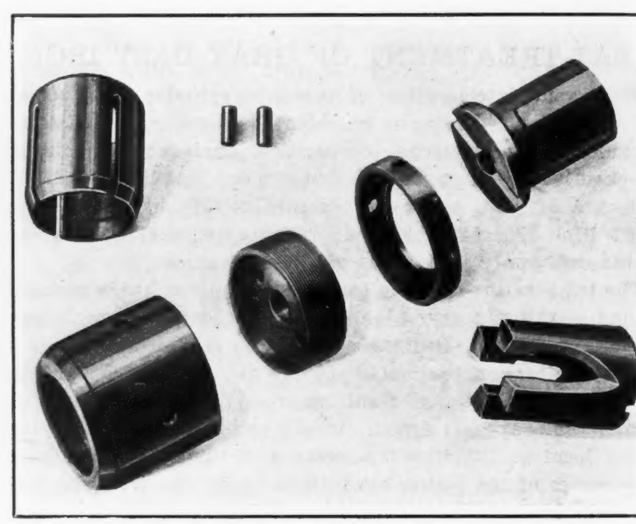


Fig. 30. Spring Screw Threading Die-holder shown in Fig. 34, dismantled to show Construction

Spring Screw Threading Dies

Spring screw threading dies are also used on the Gridley automatics, and are to be preferred to button or round dies, if properly handled, because of the possibility of securing more accurate adjustment. The cutting lands are wide, giving adequate support to the cutting edges and insuring the cutting of a thread to correct lead. They are, in addition, easier to sharpen, and have more chip room than a button die.

Sharpening Spring Screw Threading Dies

There are several points in connection with the sharpening of spring screw threading dies that should be closely observed. These have particular relation to the location of the cutting edges of the prongs relative to the center, and to the equal contraction of the prongs when adjustment for diameter is necessary.

For cutting steel, as shown at *A*, Fig. 31, the cutting edge of the die should be set ahead of the center, the amount being governed by the diameter of the part being threaded and the pitch of the thread. It is generally about one-tenth the diameter, although to provide for resharpening it may be a little more. The setting of the cutting edge ahead of the center gives a freer and cleaner cutting action. The faces also are set at a certain angle with reference to the radius of the thread, and in future grinding this relation should be preserved. At *C* is shown a spring screw die that is improperly ground; the proper face angle has not been preserved. Of course, all lands must be ground to the same angle and at the same distance ahead or back of the center, as the case may be.

For brass, as shown at *B*, the cutting edge of the prongs should be set exactly on the center, or a little behind it. When new, the cutting edge is set on the center, which allows for resharpening without impairing the cutting action of the die.

At *A*, Fig. 32 is shown the correct form of grinding wheel for sharpening spring screw threading dies when grinding on the face of the lands or prongs. It is known as a "dished" wheel and should be of a coarse enough grain and soft enough bond not to burn the die. It is preferable to grind dry, taking light cuts. The die should be held in a fixture provided with an accurate indexing head so that all prongs will be ground in the correct relation to the center.

It is seldom necessary to grind a spring die in the throat—that is, where the first few threads are chamfered to facilitate the die starting on the work. When this is necessary, however, the grinding should be carefully done and the proper wheel, which is shown at *B*, should be used. This wheel, which is cone shaped, is used to grind each prong separately, and care should be taken to see that all prongs are ground to the same angle and also to the same depth. If the angle or depth varies on the different prongs, the work is thrown onto two lands, with the result that

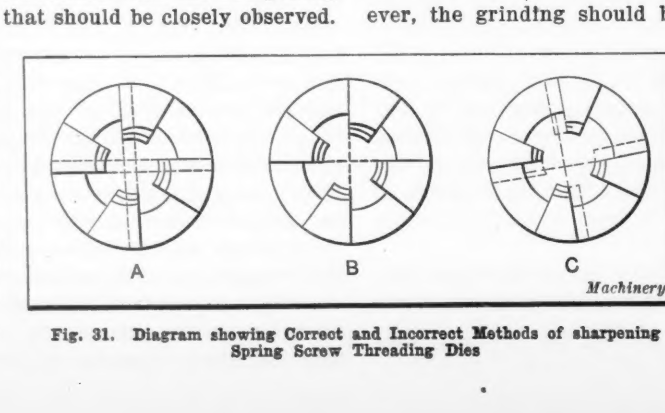


Fig. 31. Diagram showing Correct and Incorrect Methods of sharpening Spring Screw Threading Dies

[1]Address: 45 Woolson Ave., Springfield, Vt.

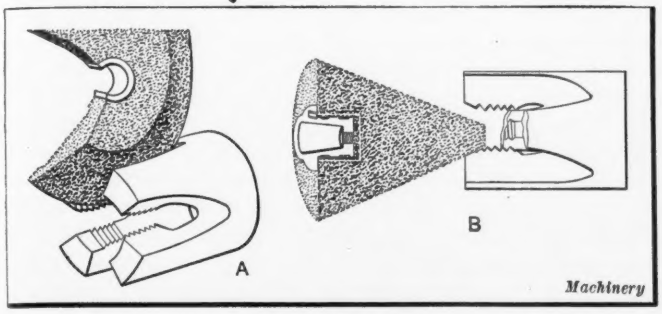


Fig. 32. Diagram showing Grinding Wheels used, and Methods of sharpening Spring Screw Threading Dies on Faces of Lands and in Throat

each prong does not perform its share of the work. If considerable grinding is done in the throat, and particularly if there is a shoulder on the piece to be threaded, a corresponding amount should be ground off the ends of the prongs to allow the die to cut up on the work to the required distance.

Another point that should receive careful attention is the position of the spot on the die for the set-screw in the holder. In the case shown at *A*, Fig. 33, the flat for the set-screw has

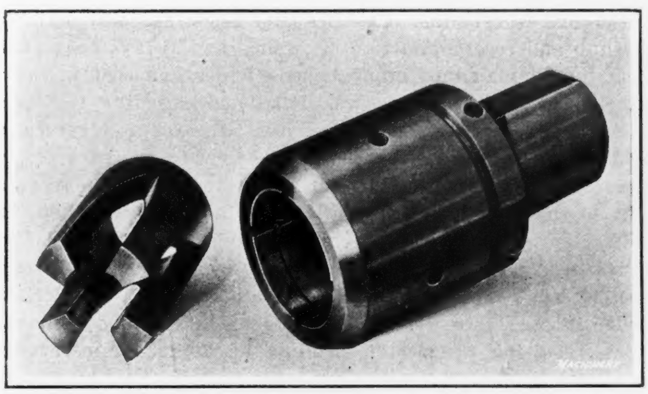


Fig. 34. National-Acme Collet Type Spring Screw Threading Die-holder

been placed so that tightening the screw closes one of the prongs, thus throwing most of the cutting onto one land. Instead, the spot should be located between two prongs, as shown at *B*, and it should be small enough so that it will not weaken the die. It is preferable not to have any flat at all, but to use a cupped set-screw, which will effectively prevent the die from turning.

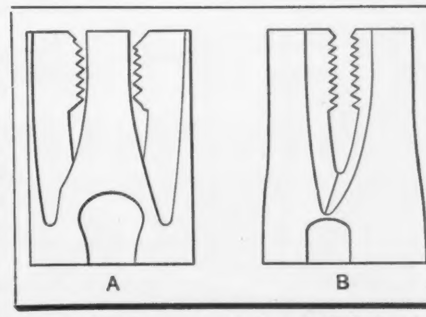


Fig. 33. Incorrect and Correct Methods of spotting Spring Screw Threading Dies for Set-screw

In order to overcome the objection of improper clamping, the National Acme Co. has designed a special die-holder, illustrated in Fig. 34. This holder, shown disassembled in Fig. 30, comprises a shank on which the die-holder is retained by a locking nut. The spring screw die is held in an adjustable spring chuck that is effectively closed on the die by a collet that fits over it. A good feature of this holder is that it allows the die to float and thus accommodate itself to the work; in addition, it is not driven by a set-screw clamped onto its exterior surface but by two pins fitting in slots in the end of the die. This holder holds spring dies accurately and prevents the troubles usually experienced with dies of the spring variety.

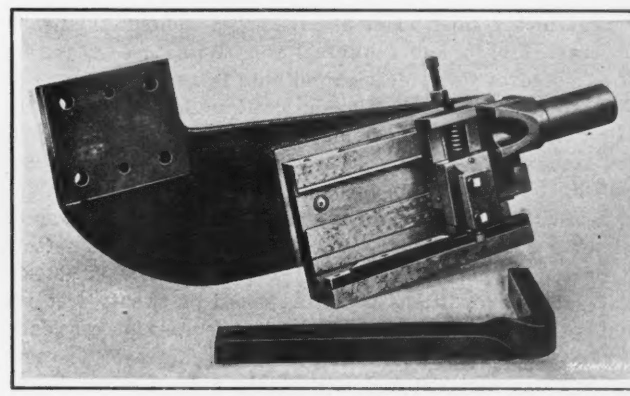


Fig. 35. Taper-turning Attachment for Gridley Multiple-spindle Automatics

Speeds for Threading

The speed of threading is determined by the type of die, material from which it is made, material being threaded, diameter and pitch of threaded part, and the cutting lubricant or coolant used. For die-heads of the chaser type, it is customary to use chasers made from high-carbon steel for threading cold-rolled steel or screw stock, Bessemer open-hearth steel, 3 to 5

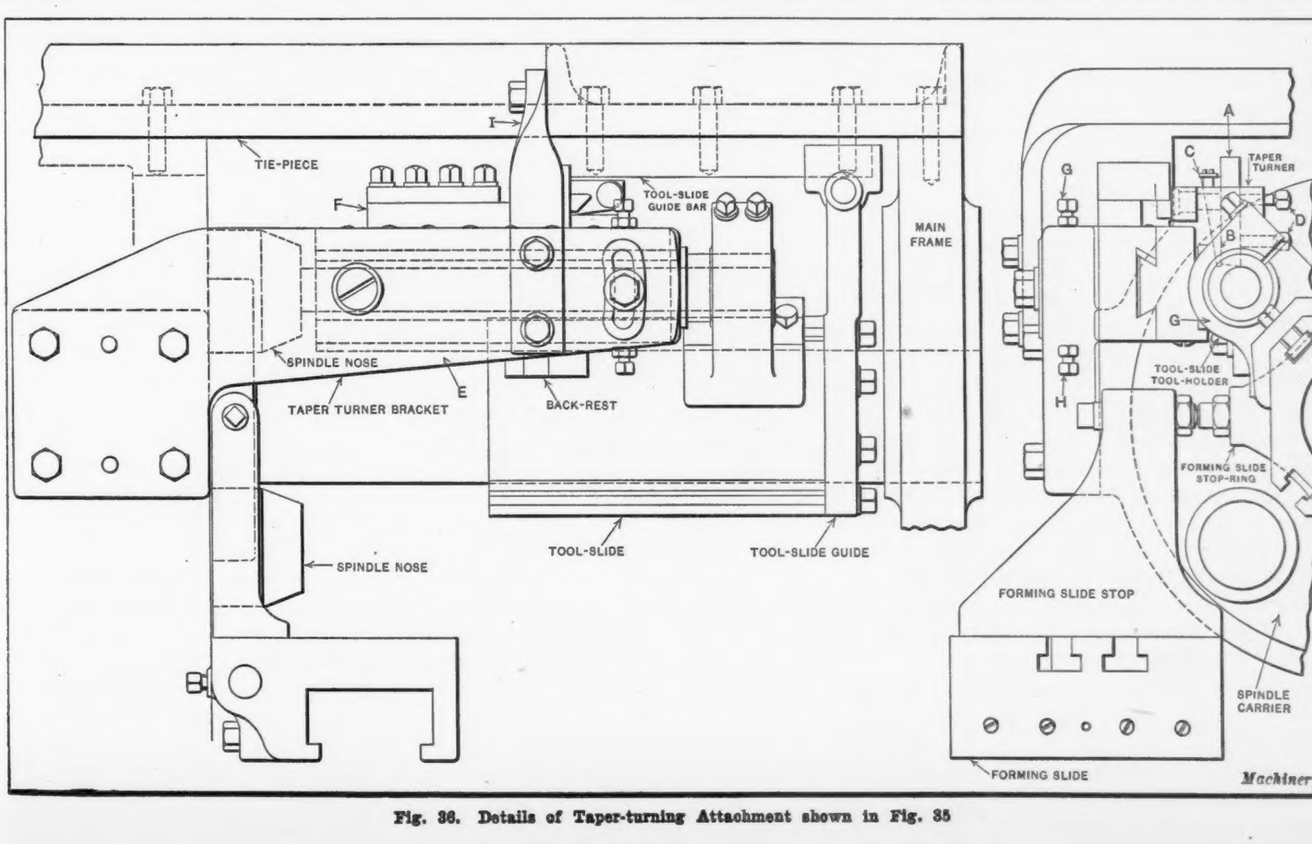


Fig. 36. Details of Taper-turning Attachment shown in Fig. 35

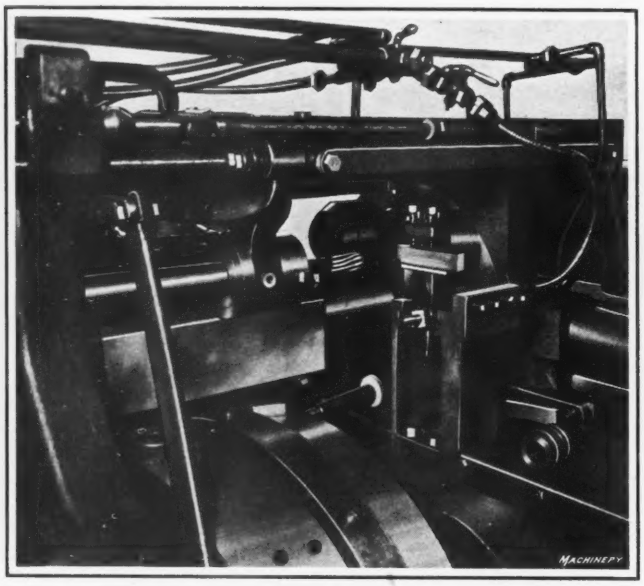


Fig. 37. Threading Mechanism being used for Accelerated Reaming

per cent nickel steel when of low-carbon content, malleable iron, brass, bronze, and similar alloys. With these chasers a cutting speed of thirty feet per minute is generally found to be satisfactory. The question of cooling the work and the chasers, however, sometimes makes it necessary to reduce the speed somewhat; whereas on pitches below twenty threads per inch, it is possible to increase the speed 20 per cent.

It is advisable to use chasers made from semi- or high-speed steel when cutting chrome-vanadium steel, tough alloy steels, cast iron, drop-forgings, and all other heat-treated steels. Under average conditions a cutting speed of twenty feet per minute will be found satisfactory; in the case of especially fine pitches, though, it may be possible to increase the speed from 20 to 50 per cent and still obtain a good clean thread, without danger of damaging the chasers. For spring screw dies, the speed of threading is generally equal to that of the chasers, although in some cases the conditions are such that a high speed is inadvisable.

Die-spindle Used for Accelerated Reaming Attachment

When it is necessary to ream a hole which is of a depth greater than the maximum travel of the tool-slide, the die-spindle in the third position, see Fig. 37, can sometimes be effectively used for this purpose. As has been previously stated, the die-spindle is independently driven and is advanced toward the work, to start the die, by a cam located on the edge of the drum carrying the cam for the operation of the stock feed. By changing the shape of the die-spindle cam and substituting one having the required throw, the die-spindle can be advanced to the required distance. When used for accelerated reaming, the die-spindle is not revolved, but is simply moved back and forth by the special cam.

Taper-turning Attachment

In the production of taper pins and similar work, when the length of the taper is too long to be produced by means of a forming tool, it is necessary to use a taper-turning attachment. The standard type of taper-turning attachment used on the Gridley automatics is shown in Figs. 35 and 36. This attachment, as shown in Fig. 36, consists of a bracket or arm *E*, which is fastened by bolts to the main frame of the machine, at the work-spindle end, and carries a slide that can be set to the required taper. The taper-turning tool proper is provided with a roll that works in a holder which is held in a standard holder clamped to the tool-slide in the regular manner. The taper-turning tool-holder carries a turning tool *A*, which is of the radial type and is adjusted for height, relative to the center of the work, by a taper wedge *B* and a collar-head screw *C*. The turning tool is rigidly clamped by two set-screws *D*.

The bracket *E*, which carries the taper guide holder *F*, has a dovetail groove cut in it in which the taper-turning tool-holder is retained by means of an adjustable gib, as shown in the end view. This guide can be swung to the desired angle by operating the screws *G* and *H*, which are provided with lock-nuts. The support for the work consists of a fixture with two rolls traveling on the work just ahead of the turning tool. This is the same holder that is used in the first position to support for forming, and is provided with a turning tool to remove a chip sufficient to give the rolls a smooth travel. The holder carrying the turning tool is operated against the tension of a spring, and on the return stroke the tool is relieved from the work, to obviate the production of the mark generally produced by a returning tool that is in contact with the work. This taper-turning attachment can only be used in the second position.

* * *

SWELLING OF ZINC BASE DIE-CASTINGS[1]

The National Cash Register Co. has had the die-casting process in operation for several years, and many parts have been produced in zinc base metal. The Cuban office complained against these castings, claiming that the metal swelled and caused trouble by binding. The castings causing most of the trouble were type wheels. These wheels have a hub casting on one side, with a recess on the other in which the hub of the next wheel runs. The dies gave 0.001 inch play between the hub and recess, and this allowance had always been sufficient for the machined bronze wheels which had been in satisfactory service for many years. It seemed incredible that this alloy should swell after having been die-cast and carefully inspected with gages, so twelve type wheels were carefully measured at four points on each wheel, and six of these were sent to the Havana office, while the other six were kept at the factory. Six months later the wheels were returned and remeasured. The results were that the wheels sent to Havana swelled 0.007 inch, while those held at the factory swelled 0.0017 inch. Tests were then conducted at various temperatures, resulting in greater swelling at higher temperatures in moist air.

The following lines of investigation were followed up to determine the cause of the swelling:

1. The effect of casting temperature.

The casting temperature was varied between wide limits. This did not have any influence on the annealing.

2. The effect of casting pressure.

The pressure was varied from 15 pounds per square inch to 200 pounds per square inch without changing the tendency to swell.

3. The effect of swelling.

Castings were annealed at various temperatures in ovens and oil baths. They were given different rates of cooling, but this did not overcome the difficulty.

4. The effect of oxidation.

Oxidation was prevented by nickel-plating and by lacquering. This procedure did not eliminate the swelling.

The effect of changes in the composition of the alloy was then tried. The zinc base alloy which was used for the casting work analyzed as follows: copper, 5.5 per cent; tin, 7.5 per cent; aluminum, 1 per cent; and zinc, 86 per cent. The first change was a decrease of the copper content. It was found impracticable to reduce the copper below 3 per cent. However, this reduction did not reduce the swelling tendency. The fact that certain aluminum alloys after a time fail by cracking and warping suggested trying the effect of different percentages of aluminum. Three alloys were made and compared with the regular metal. These alloys were cast into type wheels for comparison. In a test in moist atmosphere at 176 degrees F., the regular metal containing 1 per cent aluminum swelled 0.020 inch on a 2-inch diameter, while an alloy containing 0.1 per cent aluminum swelled 0.003 inch. These figures are averages of readings on six different wheels at four points on each wheel. The results showed conclusively that the reduction of the aluminum to 0.1 per cent practically eliminated the swelling. The analysis of this alloy was: copper, 3; tin, 7.5; aluminum, 0.1; zinc, 89.4 per cent. If the regular metal is run into pigs and allowed to cool slowly, as in standard foundry practice, no swelling will take place. This has been demonstrated on a cube which has been kept in a moist atmosphere at 98 degrees F. for over two years.

[1]Abstract of an article by H. M. Williams, Chemist and Engineer of Tests, National Cash Register Co., published in the Journal of the American Institute of Metals, September, 1917.

LETTERS ON PRACTICAL SUBJECTS

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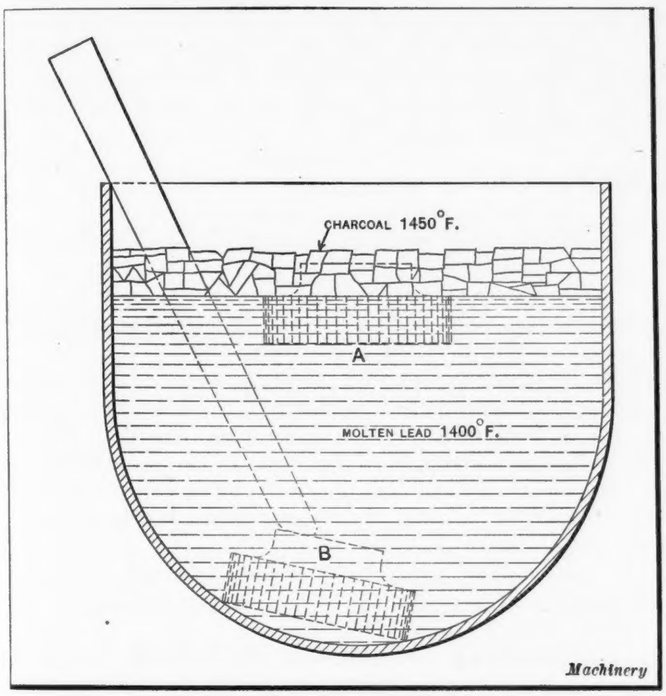
CAUSE OF GEARS WARPING WHEN HEATED IN MOLTEN LEAD

The illustration shows a lead pot in which gears are being heated in lead, with charcoal covering the molten metal. If the lead is kept at 1400 degrees F., the charcoal will be 1450 degrees F. The gear will float on top of the metal as shown at *A;* consequently the bottom becomes hot much quicker



Gears being heated in Lead Pot

than the top, but before the gear is ready to be taken out and quenched the top will be the hotter. If the gear is forced to the bottom of the lead pot and held there by a weight, as shown at *B*, the gear becomes strained and warped. The fact is that a gear cannot remain true if heated in lead, cyanide or any molten baths, because they heat too quickly. The outside of the gear is 1400 degrees F. before the core or inside is even red, and unless a gear, or any piece of steel, is heated slowly so as to allow all sections to heat alike, it is bound to distort and lose its shape.

Lansing, Mich. J. F. Sallows

ERROR IN WIRE METHOD OF MEASURING WORM THREADS

Screw threads, worm threads, threaded plug gages, taps, etc., have for many years been measured by the three-wire method, which is ideal for checking the correct pitch diameter, and the angle of inclination for the walls of the thread. If any degree of accuracy is required, it is necessary that the diameter of the wire be correct to 0.0001 inch and that the exact reading be known. It is desirable for the wires to come tangent at the pitch circle, but in the case of worm threads they are often calculated to come just flush with the top of the thread. This brings the points of tangency just below the pitch circle, but it decreases the chances of making an error when taking the reading. The illustration shows a section through a worm thread taken parallel to the axis of the worm, showing a circle that comes tangent at *B* and is flush with the top of the thread, the points *B* coming just below the pitch line. From the formula for a standard worm thread the space at the top of the thread equals $0.665P$. Hence the diameter of the circle is: $2(0.3325P \tan 37$ degrees 45 minutes $= 0.5149P = 0.5149$ divided by the number of threads per inch.

In our best handbooks are found several tables of wire sizes for measuring threads that were computed from the above formula, and while this formula is correct for a circle or for a knife-edged disk placed parallel to the axis of the thread, it cannot be used for a wire unless the wire is to be used in a groove cut at right angles to the axis without any spiral whatsoever. Every thread, no matter how slight the lead, must form a series of spirals and every spiral must have an angle to the axis. Unless these angles are considered, a correct reading over three wires is impossible. The error may be slight for fine threads or for large diameters, but it increases rapidly as the angle of the spiral becomes greater than 2 degrees. As an example, consider the worm shown in the illustration to have 1¼ inch linear pitch, 3.8 inches pitch diameter, 4.596 inches outside diameter. From any handbook select a wire size that is supposed to come flush with the top of a standard 29-degree worm thread, 4/5 threads per inch, or figure the size from the formula given above, and the

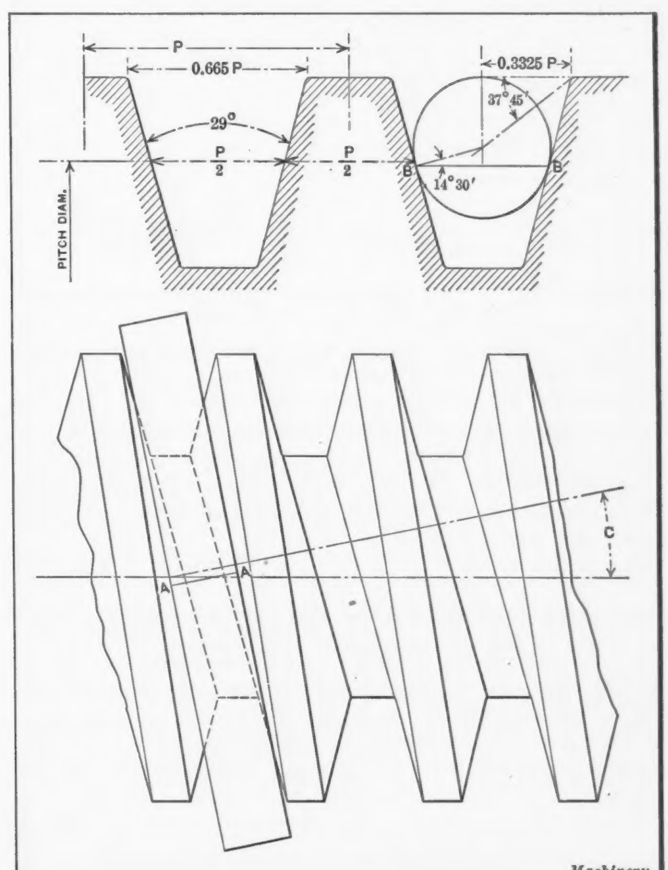


Diagram showing Error in measuring Worm Threads

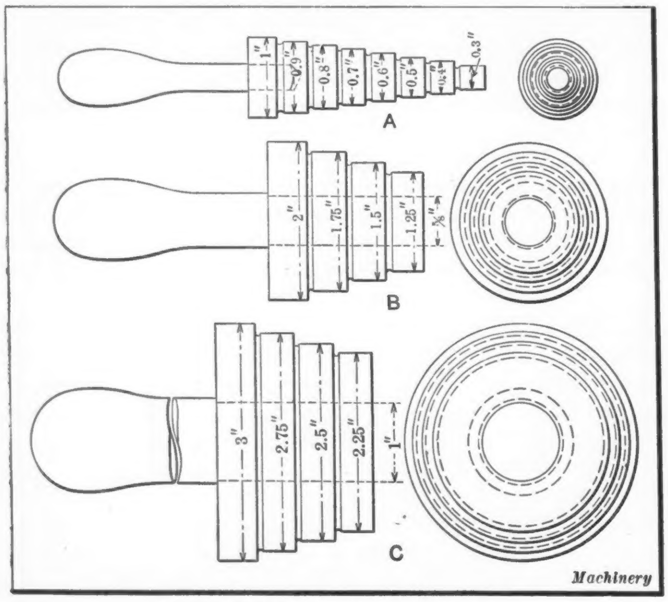
result is 0.6436 inch diameter. If this wire is laid in the groove of a finished worm, it does not cross the axis at right angles but is inclined an amount equal to the angle of spiral *C* formed by the worm on which the points of contact *A* fall. The tangent of this angle equals pitch of thread divided by 3.14159 times diameter of circle on which points of contact *A* fall, or in this case about 6 degrees. The length of the chord *B-B* equals cos 14 degrees 30 minutes $\times$ 0.6436 = 0.6231 inch. The length of the chord *A-A* equals cos 6 degrees $\times$ 0.6231 = 0.6196 inch. This means that if the walls of the worm are reduced until the 0.6436 inch diameter wire will come flush with the top of the thread, the walls of the tooth

will be 0.0035 inch too thin. This error becomes greater as the angle of the spiral increases.

Philadelphia, Pa. HOWARD H. WRIGHT

MICROMETER TEST GAGES

It is the work of the writer to inspect and adjust micrometers to get uniform and accurate results. For this purpose he has designed the test gages shown in the illustration, which have been found helpful. In testing with pin gages, the pin often expands, due to the heat of the hand, thus giving a false test. These gages were rough-turned, hardened and ground to within 0.005 inch, and seasoned for a period of six months to insure retention of size and shape. They were then finished, ground and measured on a Pratt & Whitney precision measuring machine. The gage A was made to standardize in tenths of inch, from 0.3 to 1 inch, and B and C to standardize in quarters of an inch, from 1.25 to 3 inches. The



Convenient Gages for testing Micrometers

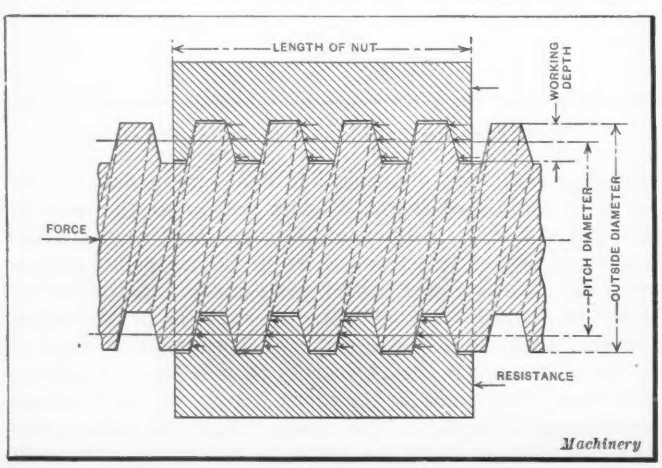
handles are made of wood to reduce the weight, but, if desired, the gages could be made in one piece.

Frequently the lead of a micrometer screw will vary as much as 0.0003 inch, and these gages are extremely useful in detecting such a condition. In large shops where micrometers are issued from the tool-cribs, there is always danger of sending the micrometers out unfit for accurate work, and here these gages are invaluable.

Willow Grove, Pa. HARRY CROWTHER

FINDING EFFECTIVE BEARING AREA OF ACME SCREW THREADS

It frequently becomes necessary to obtain the pressure per square inch on Acme screw threads; the accompanying table has been arranged to reduce to a great extent the figuring required in finding the bearing area. The projected bearing



Effective Bearing Area of Acme Screw Threads

TABLE FOR FINDING EFFECTIVE BEARING AREA OF SCREWS

Threads per Inch	Single Working Depth, Whole Depth Minus 0.01 Inch, Inch	Projected Bearing Area per Thread at One Inch Pitch Diameter, Square Inch	Projected Bearing Area per Inch C at One Inch Pitch Diameter, Square Inch	Threads per Inch	Single Working Depth, Whole Depth Minus 0.01 Inch, Inch	Projected Bearing Area per Thread at One Inch Pitch Diameter, Square Inch	Projected Bearing Area per Inch C at One Inch Pitch Diameter, Square Inch
1	0.5000	1.6480	1.6480	5	0.1000	0.3148	1.5740
1⅓	0.3750	1.2108	1.6144	6	0.0833	0.2620	1.5724
1½	0.3333	1.0702	1.6053	7	0.0714	0.2245	1.5718
2	0.2500	0.7952	1.5905	8	0.0625	0.1965	1.5720
3	0.1667	0.5266	1.5798	9	0.0555	0.1744	1.5700
4	0.1250	0.3938	1.5755	10	0.0500	0.1571	1.5715

Machinery

surface for the various threads per inch has been calculated for nuts of unit dimensions (one inch pitch diameter and one inch long); therefore, to obtain the effective bearing surface for any nut it is merely necessary to multiply the value given by the pitch diameter of the screw and by the length of nut. Stated as a formula:

$$A = (D - W)\,LC$$

in which A = effective bearing area;
D = outside diameter of screw;
W = working depth of thread;
L = length of nut;
C = projected bearing area per inch of screw.

The projected area per thread and the working depth of the tooth are also given for convenience.

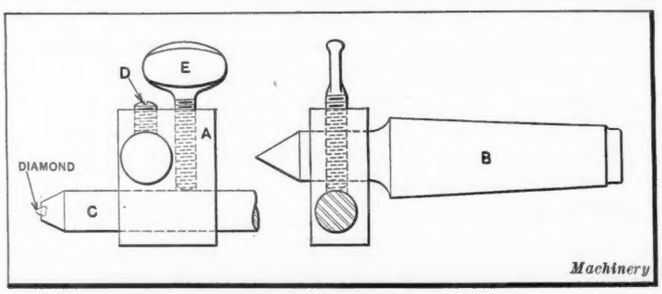
Example—Find the effective bearing area of an Acme screw that has an outside diameter of 3¼ inches, 1½ thread per inch, and works in a nut 6 inches long. The table shows that the working depth W of a screw having 1½ thread per inch is 0.3333 inch and that the projected bearing area per inch C is 1.6053. Substituting these values in the formula given:

$$A = (3.25 - 0.3333) \times 6 \times 1.6053 = 18.4277 \text{ square inches.}$$

Philadelphia, Pa. HARRY S. KARTSHER

HANDY DIAMOND HOLDER

The device here shown will be found very satisfactory for holding the diamond when truing the face of wheels in a universal grinding machine. A is the holder, B is the tailstock center, and C is a piece of round stock in which the diamond is set. The holder is held in position by the set-screw

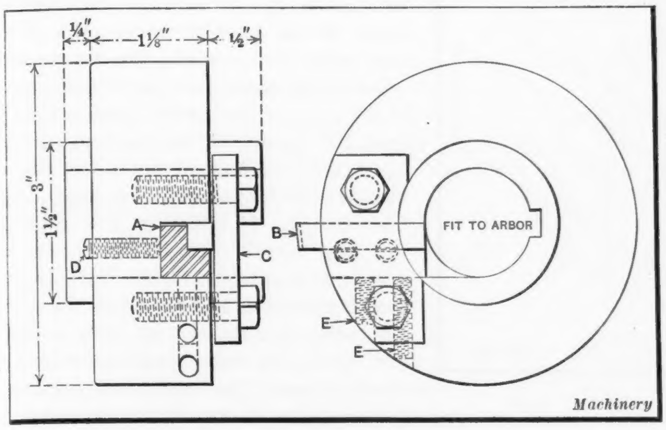


Device for truing Wheel of Universal Grinder

D while the thumb-screw E serves to secure the diamond in position when needed. With this device, it is possible to true up the wheel without removing the work. S. C.

FLY CUTTER ATTACHMENT FOR MILLING MACHINES

In the accompanying illustration is shown a tool-holder attachment that will be found especially useful in cases where there are a number of different forms to be milled but no milling cutters of the desired shapes on hand. Special arbors are not required, the tool-holder being mounted on the same arbor as the milling cutters. The tool-holder shown is made to fit a one-inch standard arbor; but for large, heavy work, a holder six inches in diameter should be made. With holders of both these sizes, many different classes of work can be done. The tool B is placed in the reducing sleeve A and is set against



Fly Cutter Attachment for Milling Machine

the arbor, to prevent its slipping backward. By means of the reducing sleeve, any tool up to one-half inch can be used. Strap *C* holds the tool in place, while it can be set by two screws *D*. Screws *E* take all lost movement out of the reducing sleeve *A* and also serve as binding screws.

Ambridge, Pa. AUGUST J. LEJEUNE

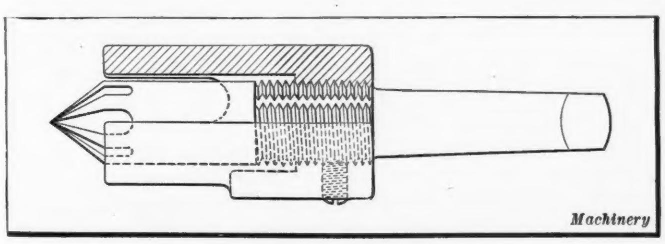
GEAR CUTTING ON SLOTTING MACHINE

The writer desired to cut a spur gear with 49 teeth, 2 diametral pitch, but as he had no cutter for that pitch, it was impossible to do the work on a gear-cutting machine, so the gear blank was mounted on a slotting machine. The shaft that revolves the slotter table was then turned until the table had made one complete revolution, and the ratio was 146:1. As there were 49 teeth to be cut, 2 48/49 turns of the crankshaft were required for the correct spacing. The worm-shaft of a dividing head was then connected with the crankshaft, and by using the circle with 49 holes, the correct spacing was easily obtained. By the use of Grant's odontograph table, the outline of a tooth for a 49-tooth, 2-pitch gear was drawn, and from this a gage was made for grinding the finishing tool. This method produced a gear satisfactory in every way.

Washington, D. C. WILLIAM F. GROVER

STOP-COLLAR FOR COUNTERSINK

The illustration shows a stop-collar that may be of interest to the readers who design or use counterbores, boring and facing bars, or countersinks. By milling slots in the stop-



Slotted Stop-collar mounted on Countersink

collars the chips can readily escape, and friction is reduced when the collar strikes the work; there is also less danger of the tang of the countersink shearing off, due at times to the operator forcing the stop-collar against the work. The slots in the countersink are milled slightly beyond the depth of the thread, and the number of slots depends upon the diameter of the countersink and the size of set-screw used. A practical adjustment is assured if the distance between the slots is uniform.

Covington, Ky. FRANK LANG

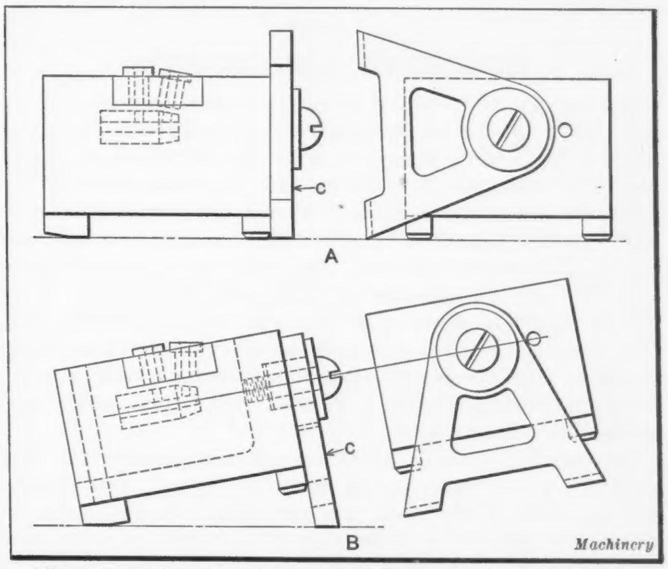
TO PREVENT LOOSENING OF TAPER SHANK DRILLS AND COLLETS

When the taper shank of drills or the surface of drill collets becomes worn and scored, it is difficult to make them stick in the drilling machine spindle. Sometimes rubbing a little chalk on them helps greatly. When this fails, as it will on work where the drill is likely to "dig," the drill or collet can be securely held by rubbing it with a piece of waste moistened with turpentine. It will be found that even the hardest service will not loosen them. In fact, the only way the drill or collet can then be removed is by using the drift.

East Walpole, Mass. JAMES A. KIRK

JIG FOR STRAIGHT AND ANGULAR DRILLING

The writer designed the jig shown in the illustration for drilling two holes, one of which was on an angle. By the use of this jig, the operator can bring the jig quickly into the correct position for drilling the two holes. When drilling the straight hole, the jig is in the position shown at *A*, and when the operator wishes to drill the angular hole, he simply lifts the front of the jig, and the swinging leg *C* falls down, thus



(A) Jig in Position for drilling Straight Hole. (B) Jig in Position for drilling Angular Hole

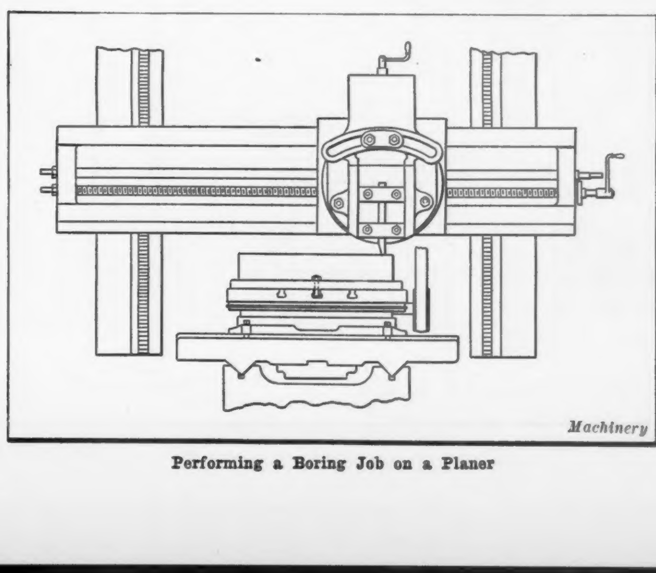
bringing the jig into the position shown at *B*, and placing the hole to be drilled in a line with the drill. By using this jig, extra parts, such as a cradle or angle-block, are eliminated.

Hartford, Conn. JAMES W. BOYCE

USING PLANER AS BORING MILL

Some time ago it was necessary to do a large boring mill operation in a shop where a boring machine was not available. The illustration shows the method used in doing the work. A revolving milling machine table was securely bolted to the platen of a planer. Then the axis of rotation of the milling machine table was placed in a line perpendicular to the travel of the tool on the planer head. The regular planer belts were thrown off and a small pulley was mounted on the milling machine table to take the place of the crank, the pulley being driven by a belt from a convenient countershaft. The operation was then satisfactorily performed.

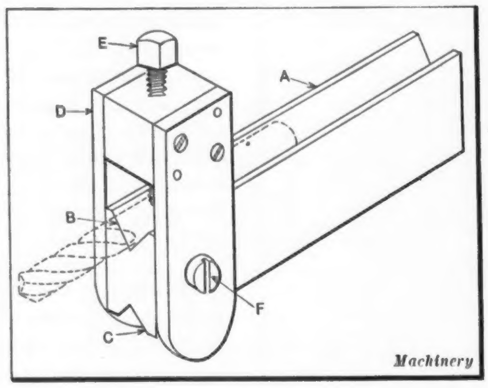
Jackson, Mich. RICHARD GIBBS



Performing a Boring Job on a Planer

DRILL-HOLDER FOR THE LATHE

The accompanying illustration shows a tool-holder for small drills to be used in the toolpost of a lathe. Its convenience will be evident to anyone who has had to drill small work held in the lathe chuck. The drill may be easily removed, ground and replaced in identically the same position. As will be seen, the shank *A* has two grooves *B* and *C*, one larger than the other, to accommodate varying sizes of drills. The clamp *D*, carrying the clamping screw *E*, can be swung around pivot *F* and used with either groove.



Drill-holder to fit in Toolpost of Lathe

Brooklyn, N. Y. ERNEST SCHWARTZ

CONCRETE AGGREGATES

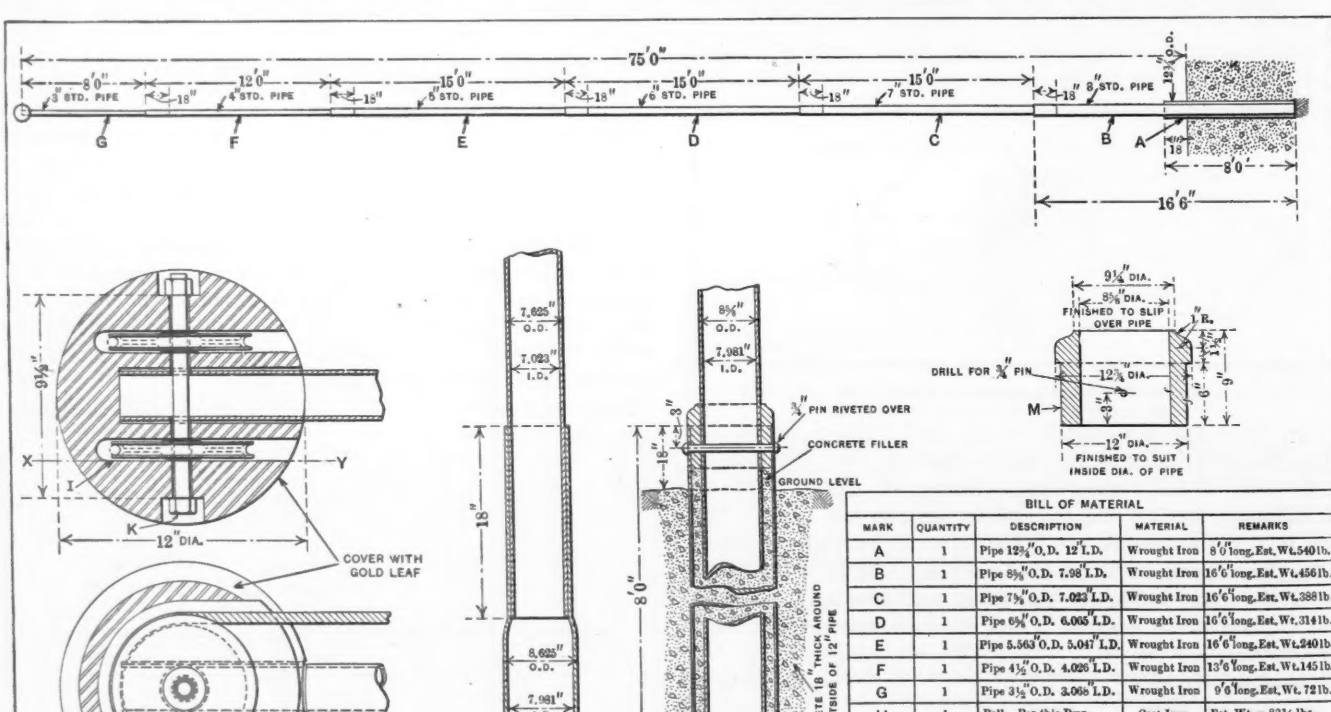
Apropos of the article on washing concrete aggregates in the November number of MACHINERY, the writer would say that general usage in the matter of proportion of cement and aggregate (for instance, the 1-2-3 method) is wrong, being either wasteful of cement or productive of a non-homogeneous mixture. Cement, like joiners' glue, should be used as a bond and not as constructive material. As little should be used as will exactly cover all adjacent surfaces; and the surfaces to be joined should be made to fit as accurately as possible. This principle of making a glue joint applies in making a cement mixture; the aggregates should fit each other closely, and not leave large spaces between to be filled with cement, which costs more than stone or sand.

For example, take a granite block and break it up into chunks that will pass through a two-inch ring. These, thrown together, will weigh much less per cubic foot on account of the interstices. If the other aggregate is granite spalls used in the proportion of 3 to 2, shoveling the two together dry will result in a bulk exceeding that of the large pieces. The proper proportion of spalls may be found by filling a barrel with the chunks in layers, filling the interstices with water until the barrel runs over, then tapping off the water and measuring it, next shaking spalls into each layer until it will hold no more; the mixture will then contain the maximum amount of spalls that should be used. If, after all is dry again, sand is sifted into the layers of blocks and spalls, until they will hold no more, the maximum desirable amount of sand has been added. If water is now poured into the barrel until it runs over, it will be seen that the total volume of all the interstices is less than was the case just after the spalls had been added, and still less than that among the blocks alone. The difference between the volume of the interstices among the blocks and that of the triple mixture will represent approximately the amount of cement saved by properly proportioning the three sizes of aggregate.

New York City ROBERT GRIMSHAW

METAL FLAG POLE

At this time all manufacturing plants should display the national flag, and the illustration shows a drawing for a pole that the writer believes to be far superior to a wooden one. It was constructed for a flag 12 by 20 feet. The pole is 75 feet above the ground level and is constructed of six sections of iron pipe that are 3, 4, 5, 6, 7 and 8 inches in diameter, with the joints shrunk together. These joints are made by inserting the smaller pipe 18 inches into the larger pipe, while the latter is at a red heat, then swaging down the heated portion and allowing it to cool. The swaging may be done either by a hydraulic press or under a hammer. Surrounding the lower piece of pipe, 8 inches diameter, is a piece of 12-inch pipe, 8 feet long, and securely held in place by concrete, and the latter pipe is sunk 6½ feet below the ground level. The space between these pipes is filled with a rich concrete, and then collar *M*, which can be moved freely over the 8-inch pipe, is slipped into position and securely pinned. At the top of the pole is mounted a cast-iron ball, 12 inches in diameter, having two 6-inch cast-iron sheaves with brass bushings, securely held in pockets in the ball by a ¾-inch bolt. Computations



BILL OF MATERIAL				
MARK	QUANTITY	DESCRIPTION	MATERIAL	REMARKS
A	1	Pipe 12¾" O.D. 12" I.D.	Wrought Iron	8'0" long. Est. Wt. 540 lb.
B	1	Pipe 8⅝" O.D. 7.98" I.D.	Wrought Iron	16'6" long. Est. Wt. 456 lb.
C	1	Pipe 7⅝" O.D. 7.023" I.D.	Wrought Iron	16'6" long. Est. Wt. 388 lb.
D	1	Pipe 6⅝" O.D. 6.065" I.D.	Wrought Iron	16'6" long. Est. Wt. 314 lb.
E	1	Pipe 5.563" O.D. 5.047" I.D.	Wrought Iron	16'6" long. Est. Wt. 240 lb.
F	1	Pipe 4½" O.D. 4.026" I.D.	Wrought Iron	13'6" long. Est. Wt. 145 lb.
G	1	Pipe 3½" O.D. 3.068" I.D.	Wrought Iron	9'6" long. Est. Wt. 72 lb.
H	1	Ball. Per this Dwg.	Cast Iron	Est. Wt. = 83½ lbs.
I	2	6" Sheave Wheels	Cast Iron	Est. Wt. = 7 lbs. each
K	1	¾" Bolt, 10½" long		Hex. Nuts
L	2	Manilla Rope		145'0" long
M	1	Collar	Cast Iron	Est. Wt. = 135 lbs.

Drawing of Metal Flag Pole

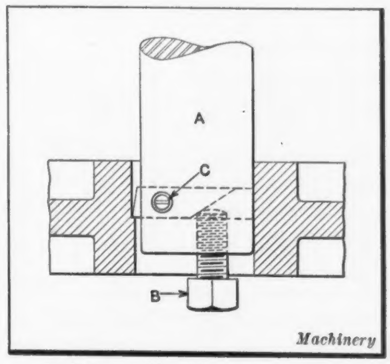
show that a load of approximately 300 pounds applied at the top of the pole will produce a stress of 17,000 pounds per square inch in the 8-inch pipe near the ground level.

Chester, Pa. GEORGE W. CHILDS

KEYWAY CUTTING TOOL FOR DRILL PRESS

The illustration shows a tool that was used for cutting keyways in a shop where the amount of work did not warrant the purchase of a keyseater. One end of bar *A* fits into the spindle of the drill press, and it is worked up and down by the rack handle on the machine. The screw *B* is given a slight turn for each stroke, thus causing the tool bit to advance, until the required depth is cut. A headless set-screw *C* is forced against the tool bit to keep it rigid. Bar *A* should be a sliding fit in the bore of the piece being machined, so that it will also be kept rigid. With this tool, keyways ¼ and ⅜ inch wide have been successfully cut.

Philadelphia, Pa. M. C. MELINCOFF



Tool for cutting Keyway in a Drill Press

IDLE MACHINE HOURS

The proposition of dealing with idle machines in the shop has come to the front much of late. It has been estimated that the cost of an idle machine may be as high as two dollars a day. In jobbing shops where no special machine is assigned to any particular person, it is hard to get a correct estimate of the number of hours a machine works each day, as the conditions governing the work are widely different from those in a manufacturing shop. However, in shops where a hundred or so machines have been installed it is essential that an account of the equipment be kept. There are occasional instances where the nature of the work is such that one or two machines may be idle for a considerable length of time before any official notices it.

Many ingenious schemes have been devised for recording the time a machine is in use and the time it is idle. The method most commonly used, however, is for the operator to put on his time ticket the number of hours worked to the nearest tenth of an hour. This method is objectionable, as the time required for the mechanic to do this clerical work should be used more economically; and as this record does not affect the workmen's pay envelope, it is often far from being correct. The following method will be found more satisfactory; the little clerical work necessary is easily done by the tool-crib attendant marking the correct time on a chart like the one shown. When a man is ready to use a machine he goes to the tool-crib for his tools. When he gives the man his tools, the attendant puts a brass check bearing the man's number on the machine chart and at the same time makes a blue mark on the chart at the proper place. When the man returns his tools, the attendant draws a short red line across the blue line at the proper place. The distance from the beginning of the blue line to the red cross-line shows the time the machine was busy. A man who requires any kind of machine will inquire of the tool-crib attendant, who can at any time tell immediately what lathe, planer, shaper or drill press is idle, and thus makes it unnecessary for the men to walk about the shop trying to locate a suitable machine and conversing with every workman on the various topics of the day.

New Haven, Conn. ERIC LEE

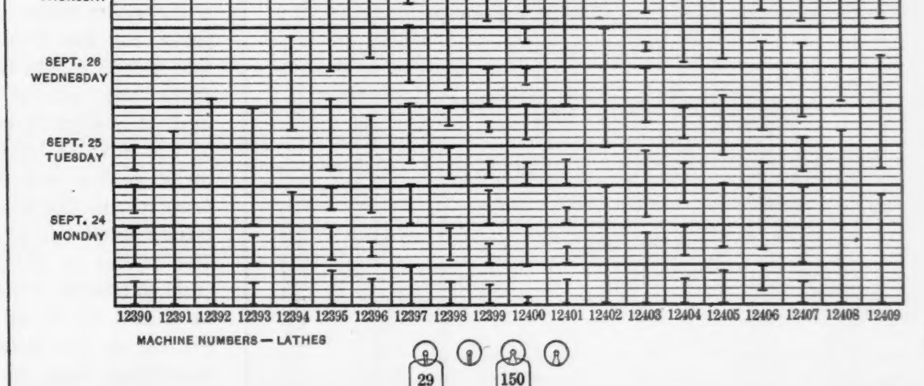


Chart showing Time Machines and Tools are in Use

AMMONIA FOR FIRE EXTINGUISHING

In a recent conversation with the superintendent of a manufacturing concern relative to a fire in its storehouse, it occurred to the writer that the use of ammonia would be an improvement on the present method of using water for protection. Combustion, in the sense that we use the word as applied to fire, depends entirely upon the supply of uncombined oxygen obtainable. The greater the quantity and quality of this gas, the more rapid and effective the fire. Naturally the supply of oxygen is obtained in the majority of cases from the atmosphere, which contains but 23 per cent, the remainder being practically all nitrogen. Oxygen is the greatest supporter of combustion known; so great that in it we can burn such refractory substances as iron, steel, diamonds, etc., depending on the purity of the gas. Nitrogen on the other hand, is the most negative element there is. Ammonia gas is composed of one part of nitrogen and three parts of hydrogen. Notwithstanding the fact that hydrogen is itself combustible, when combined with nitrogen to form ammonia, it has a peculiar effect of suffocation on the respiratory organs and seems to exert a similar action on combustion, and a little ammonia gas will go a long way toward extinguishing a good sized fire. This is undoubtedly due to the fact that it cuts off the air or oxygen supply which is so essential to combustion. To just what extent this will work can be determined by experiment.

It would seem that if a building were piped from a tank outside, containing ammonia, either in the liquid or gaseous state, similar to the present water system, that could be turned on from an outside valve or by means of fusible alloys, it would have some advantages over the present system. There would be this difference, however, that in case of ammonia the pipes should be run on or under the floor instead of at the ceiling, for the reason that ammonia, being a gas, will naturally rise and in this manner will immediately invade every part of the building, whereas if it were turned loose from above it would have a tendency to remain there, and would take some time for diffusion, especially so in the case of a higher temperature. It would, of course, be necessary to have the outlet

pipes clear at all times, which could be accomplished by having them end in a T, with one open end of the T larger than the other, and the smaller opening uppermost, which would prevent any possibility of clogging up with dirt. Two advantages that the use of ammonia has over water are that the fire can be extinguished more rapidly, and that the work will be done by a gas which can be removed by ventilation and which has little or no effect on most substances, eliminating the enormous loss that is frequently caused by water alone.

A. SCHLEIMER
Rutherford, N. J.

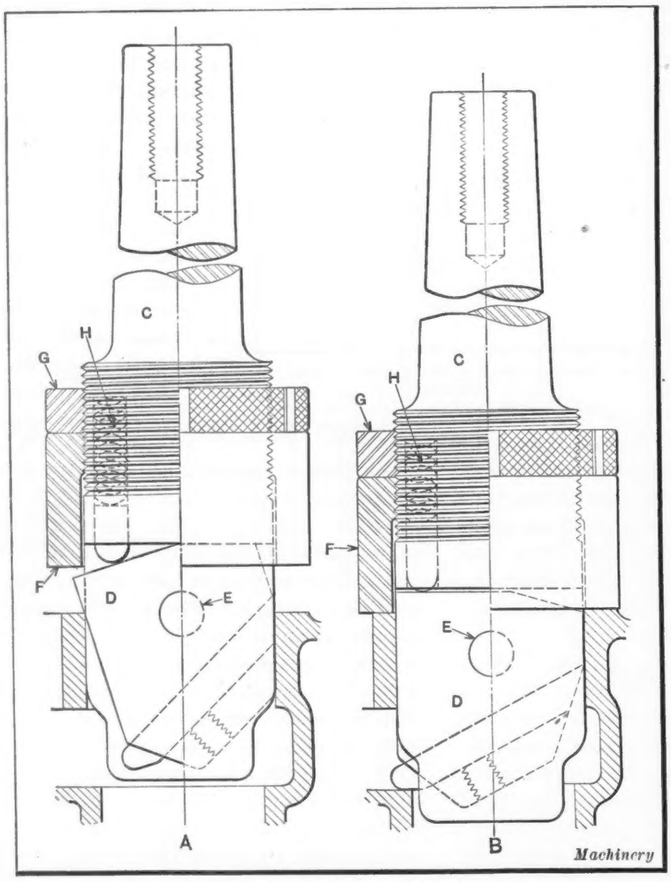


Fig. 2. Tool for facing around Valve Seat

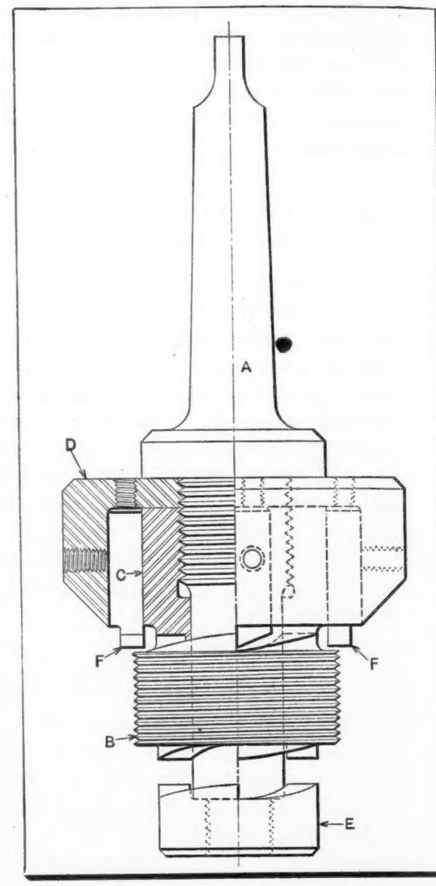


Fig. 3. Tool for machining Valve Plug Seat

CYLINDER VALVE CHAMBER TOOLS

The tools here described are used in machining the valve chambers of gas engine cylinders. The tool shown in Fig. 2 is used in facing off the surface *A*, Fig. 1, being used before the hole is tapped, and fitting into the tap-drill hole. Referring to Fig. 2, stem *C* was turned up with a shank at one end to fit the machine, and in the other end is a slot for tool-holder *D*, which is held in place by pin *E* and pivots about it, the latter being a drive fit in *C*. A square stellite tool-bit is held in holder *D* by means of a set-screw. An adjustable stop-collar *F* screws on stem *C*, and is held in place by lock-nut *G*. It is readily seen that as the tool advances into the work, as shown at *A*, the tool-bit will swing into the position shown at *B*, the stop-collar governing the depth of cut. As the tool is withdrawn, spring *H* forces *D* back into its initial position. Pieces *C* and *D* are tool steel, and *F* and *G* are casehardened machinery steel.

The tool illustrated in Fig. 3 is used for machining the valve plug seats *B*, Fig. 1, and is used after the hole has been tapped. Part *D* is screwed up against a collar, while cutter blank *C* screws under and against *D*. Four stellite tool-bits *F* are held in *C* by means of eight set-screws in *D*, and are ground in place. The plug seat *B*, Fig. 1, has a right- and left-hand set of jaws that fit into corresponding jaws on *E* and *C*. The tool is shown in the position it is in when it is started to be fed into the tapped hole in the cylinder. The threaded part of *B* acts as a pilot for the tool, making the counterbore absolutely concentric as well as perpendicular with the threads in the cylinder. The tool is fed or screwed into the cylinder until it has cut to the required depth. The machine is then reversed and the tool is pulled out until the jaws of *E* interlock with the lower jaws on *B*. Part *B* will then unscrew, releasing the tool, and the operation is complete. Parts *A*, *C*, *D* and *E* are casehardened machinery steel, and *B* is tool steel left soft.

Chicago, Ill. HAROLD A. PETERS

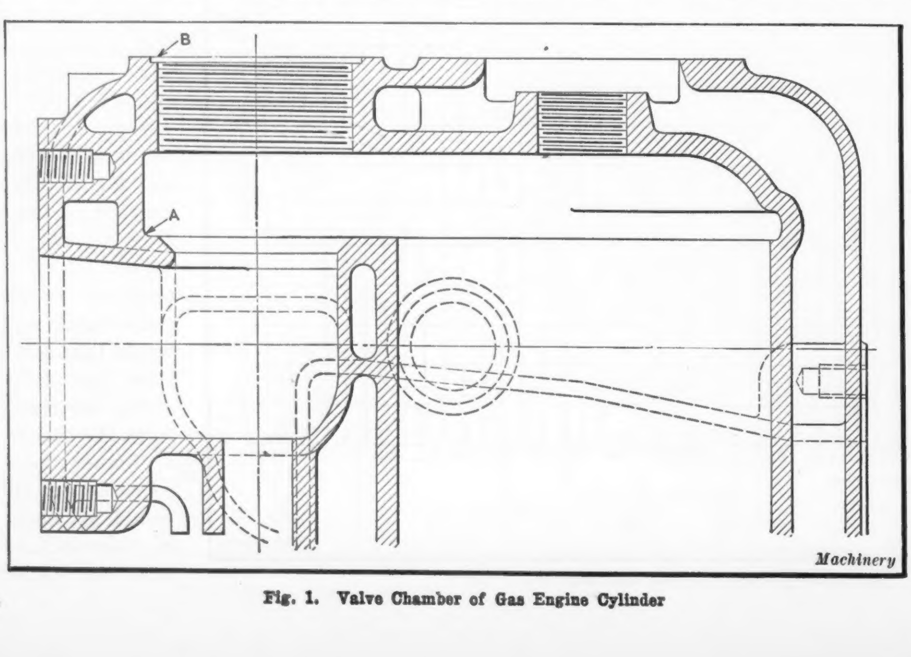
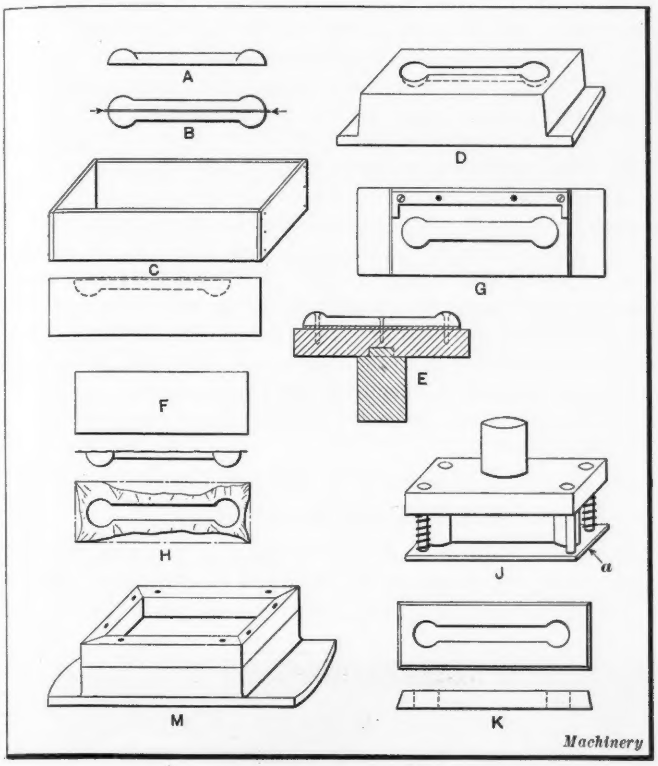


Fig. 1. Valve Chamber of Gas Engine Cylinder

ECONOMICAL DIE-MAKING

The time required in die-making may be reduced by the use of plaster of paris, as here described. In the illustration at *A* is shown the piece that is to be produced by dies. A piece of material is first turned to the required dimensions, as shown at *B*, and then sawed lengthwise. A wooden box *C* somewhat larger than the die is made. Plaster of paris should then be mixed with water until it becomes a thick paste, and box *C* is filled with it. The model *B* is carefully laid on top of this paste and gently pressed downward until it is slightly below the top surface of the box, as illustrated; as this material settles and hardens rapidly, the pressure on the model should be maintained until the plaster becomes hard. The model is then removed and the mold extracted, which may be machined as shown at *D*, or any desired shape. Filling up the holes in the mold and smoothing over is the last operation preparatory to making a steel casting die. The punch-holder *E* is made of wood and the model *B*, or a lead casting



Making Dies by the Use of Plaster of Paris

made from the die, is fastened to *E* as shown. A piece of cardboard or wood equal to the thickness of the material is placed between the punch and its holder to allow for shrinkage. The punch mold is then ready for the foundry.

A blanking die may be provided, or the metal may be cut into strips, as shown at *F*, and located upon the forming die by the nest illustrated at *G*. After the forming operation, the strip *F* will appear as shown at *H*, and it must be trimmed by the trimming punch *J* and die *K*. The formed piece *H* is inserted into the die, the punch trimming off all excess metal, which is prevented from clinging to the punch by the stripper *a*. If forming tools are to be frequently made in this manner, it would be well to have a wooden box *M* in which the plaster of paris molds could be formed innumerable times.

East Rutherford, N. J. GEORGE F. KUHNE

EFFECT OF RAPID COOLING OF CASTINGS ON MACHINING

One of the important factors in the economical production of parts from cast iron is to have an iron that will machine easily. The question of the effect of slow or quick cooling upon castings often arises. In an effort to arrive at some conclusion relative to this, a series of tests were run. The method of procedure was as follows: Rings were cast from various mixtures of iron; some of these were removed from the sand as soon as they had cooled sufficiently to handle, while others were left in the sand until they were practically cold. These rings were then placed on a boring mill and cuts were taken to determine the relative ease of machining, after which they were given a machining test by using a 3/16-inch "Novo" drill, properly ground. This drill was run a fixed number of revolutions with a constant weight upon it. The comparative depth of the holes drilled was taken as an indication of the machining qualities of the iron. Test specimens were taken from each mixture of iron handled in the foundry under exactly the same conditions as the machined rings. A condensed record of the test is shown in the accompanying table. The results show that increased difficulty in machining is to be expected with an increased rate of cooling of the metal. There were twenty different pieces tested, and although these data may not be sufficient to lay down definite information as to exactly what could be expected in every case, they indicate that a more exhaustive test along this line would be of value to manufacturers and result in a more easily machined and hence a cheaper casting.

EFFECT OF RAPID COOLING ON HARDNESS OF CAST IRON

Run No.	Casting No.	Time Casting Remained in Sand, Hours	Ultimate Tensile Strength, Pounds per Square Inch	Ultimate Compressive Strength, Pounds per Square Inch	Comparative Hardness
1	4	2	19,000	86,880	110
1	5	17	19,150	87,260	100
2	6	2½	20,700	95,610	196
2	7	17	17,800	93,630	118
3	11	1¾	20,500	97,170	197
3	14	17	20,600	100,910	139

Machinery

Manhattan, Kan. W. W. CARLSON

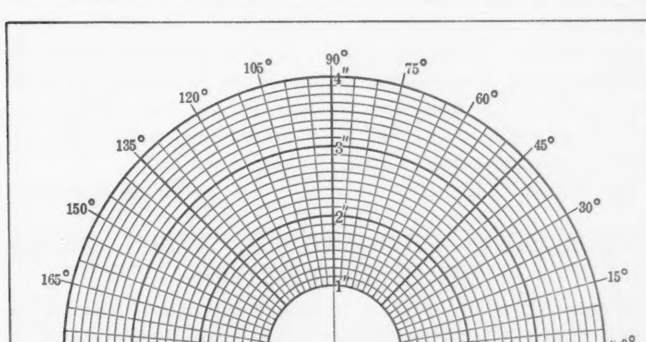
CUTTING OFF STOCK FOR LATHE WORK

In these days of efficiency and economy, it is still possible to stop many leaks of high-price material and time. One place needing reform in many shops is the shop order department or whatever other department may be responsible for cutting off stock for lathe work in the tool-room. Stock is often ordered cut to short lengths when the bar would be more economical of both time and material. The blade of a power hacksaw is sometimes thinner than the cutting-off tool used on a lathe, but the allowance that must be made for running and other inaccuracies causes a serious loss. This allowance is usually one-eighth inch in addition to the metal removed by the saw; if the diameter of the bar is more than one inch, this allowance must be increased in most cases. In the case of high-speed steel, which costs nearly five dollars a pound, a dollar's worth of material is soon converted into shavings; and unless a large amount of the material is being worked, the salvage on these shavings is slight. Besides, the saving of time in working from the bar, as compared with the short pieces, is often considerable. Most tool-room lathes have hollow spindles, and though the diameter of the hole is slightly larger in some new lathes than it was twenty years ago, in the opinion of many excellent mechanics it might be still further enlarged with benefit.

Wilkinsburg, Pa. WILLIAM S. ROWELL

TEMPLET FOR LAYING OUT CAMS

The accompanying figure is not a draftsman's artistic attempt to draw a spider web. It is merely a convenient method of drawing circular cams. In places where automatic machinery is designed there is a demand for such cams, and some convenient method of drawing facilitates experimenting with different cams, and also saves time in drawing or erasing



Cross-section Templet for laying out Circular Cams

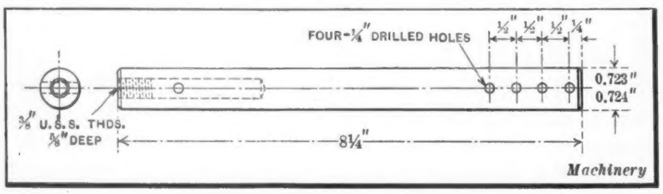
a number of times. This templet consists of concentric circles spaced about one-eighth inch apart, the largest being about six or eight inches in diameter; radial lines extending out from the center divide the circles into segments of about five degrees each. If this is inked on tracing cloth, it can be used a number of times by merely drawing, in pencil, the desired shape of cam on the tracing cloth and then changing this pencil lay-out until the right contour of cam is attained.

Chicago, Ill. RALPH R. WEDDELL

WHO BLUNDERED—THE DRAFTSMAN OR THE MACHINIST?

In the November number, page 250, an error is described and the question is asked, "Who blundered—the draftsman or the machinist?" In the writer's opinion, both were to blame; the machinist because he did not request more information, and the draftsman because the drawing was not as definite as was possible. A note should have been placed on the drawing informing the machinist that the only work required was to make the slot to the dimensions given. The great fault with many drawings seems to be the absence of notes. The draftsman often takes it for granted that the machinist is as familiar with the design as he is and neglects sufficient information. The results are mistakes in the shops. The writer has seen drawings showing only one view and a note, as "½ by ¾ inch." It can readily be seen that these dimensions could be covered by a number of shapes, such as rectangular, oval or elliptical. The correct method is to make all drawings to as large a scale as is practicable and to make them as simple as possible. A drawing should not look like a crystal maze, and the ordinary machinist be expected to interpret it, because he will not. He will do the best he can and guess the remainder.

Some time ago the writer was given a job and was supplied with a drawing like the one illustrated. It was a shaft with a number of holes drilled through it, and the end view indicated these holes by dotted lines. At one end of the shaft a hole was to be drilled through its center for about three inches. One of the holes drilled on the length of the shaft went into this hole at the end, on one side only. Owing to the fact that the various holes were shown in the end view, the



Drawing of Shaft to be drilled

fact that the hole mentioned only went part way through the shaft was not as obvious as it should have been, and the result was a number of spoiled pieces. In the writer's opinion the draftsman was at fault, but the machinist was made to shoulder the blame. If the following note (one ¼-inch drilled hole through one side only) had been placed on the drawing, the error would not have occurred.

Providence, R. I. ROBERT MAWSON

INCREASING PRODUCTION WITH MORE RIGID INSPECTION

Increased production from increased inspection may be unusual, but it is the experience of a large manufacturer of engine lathes, who has, with the increased demand, tightened the inspection all through the shop instead of letting down the bars, as might be the tendency when the plant is rushed. The inspection has been tied up with the production so that it is constructive. At each operation, the first piece of every lot is examined to be sure the workman is started right. In addition, every piece in every lot is inspected. It is not merely an inspection that places one piece into one pile because it passes the necessary tests, and another piece into another pile because it fails; but it is an inspection that finds the reason of the spoilage and prevents its recurrence. That is why increased production has resulted from increased inspection.

The inspection and time keeping have been made to work together, too. Before the timekeeper can let out a job, the piece must have been inspected for the last operation. This insures the piece being scrapped the moment it is spoiled without useless machining, and at the same time makes the timekeeper a "punch-up" man for the inspector. Not only is the work in the shop inspected, but every purchased piece as well—every cap-screw, nut and bolt. There are no men jamming over-size cap-screws into a hole and stripping the threads, nor are there parts poorly secured because the nuts ran on too hard. Also the work is standard, and there is no special filing, scraping and fitting to cause grief later if the customer needs a repair part. As a result, on the erection floor, with 70 per cent of the force used in 1914, the men are erecting 100 per cent more machines to closer limits than have ever been used before. It is small wonder that the works manager says that it seems to him that "Inspection can hardly be overdone."

Cincinnati, Ohio D. M. PERRILL

AN UNUSUAL SCREW

Recently it became necessary to make screws like the one shown at *B*, Fig. 1, and at *D*, Fig. 2, the specifications being a screw of extreme lightness, cheapness of construction and

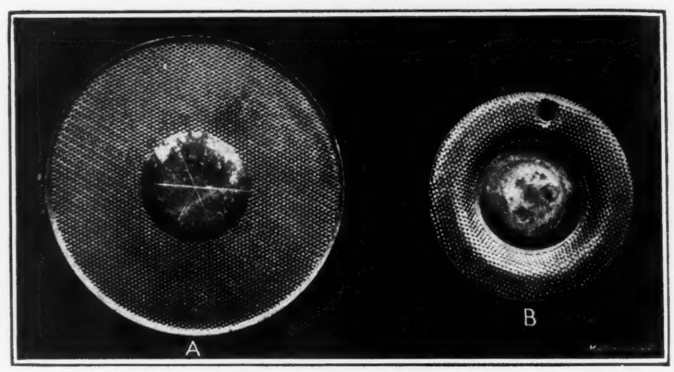


Fig. 1. Embossed Disk and Finished Screw

having a neat appearance. A circular blanking die was made that was used to stamp the disk *A*, Figs. 1 and 2, from sheet steel 0.032 inch thick. Then an embossing die was made by making a series of indentations on a die-block, by the use of a slotting machine, using a 60-degree center punch and setting the stroke to the proper height, then spacing it by the automatic feed. The clearance in the center of the die was then turned out on a lathe, and the outside was also turned so as to make a concentric die. The upper half or the punch was flat. This die completed the disk as it is shown at *A*, Figs. 1 and 2.

A drawing die was then made which drew the disk into the shape shown at *B*, Fig. 2. The screw portion, shown at *C*, was turned on screw machines from bar stock. A fixture was then

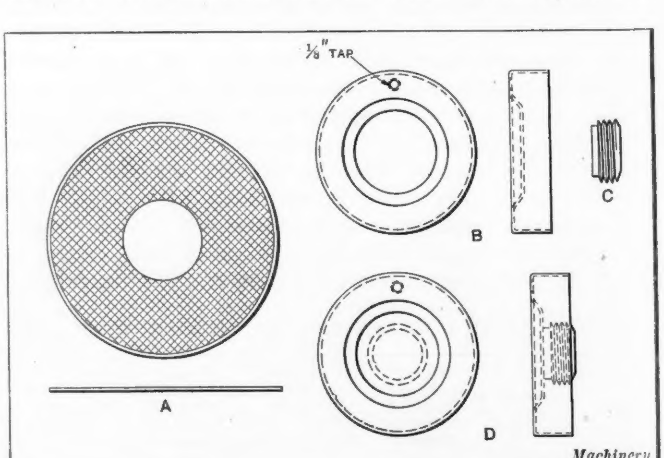


Fig. 2. Screw in Various Stages of Manufacture

made for a welding machine, holding the two pieces *B* and *C* in place while they were being electrically welded. The screw is shown in its finished form at *B* in Fig. 1, and at *D* in Fig. 2.

Elizabeth, N. J. EDWARD J. BESSOM

HOW AND WHY

QUESTIONS ON PRACTICAL SUBJECTS OF GENERAL INTEREST

TO GRADUATE A PLANER HEAD WITHOUT SPECIAL APPLIANCES

E. J. R.—Can any reader of MACHINERY suggest a way to graduate the head of a 36-inch planer in a shop where there are no milling machines or graduating machines? Any information that can be offered on the subject will be appreciated.

The question is submitted to readers for suggestions.

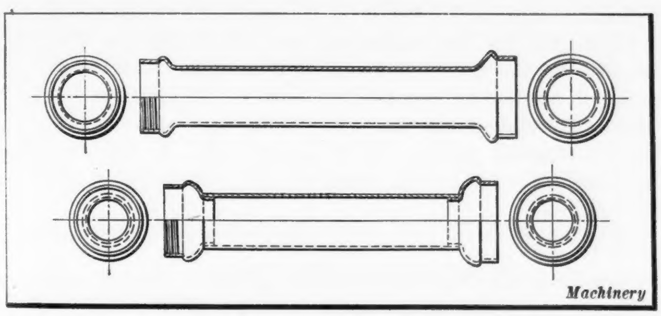
HOW TO EXPAND A THREAD PLUG GAGE

D. D.—Can any reader of MACHINERY tell me of a way to enlarge or swell a worn thread plug gage so that it can be lapped to the original size?

A.—The subject of salvaging worn gages is one of great importance, but very little has been done in this line because of the practical impossibility of increasing the diameter of a hardened plug without softening it by heat and distorting the shape. If any reader of MACHINERY can offer a practical method for expanding plug gages and thread gages so that they can be lapped to size, we shall be glad to give his article space.

TOOL EQUIPMENT FOR MAKING STUD OF A BICYCLE PEDAL

H. E. H.—The accompanying illustration shows two designs used for the central part or stud of a bicycle pedal. That shown at the top illustrates a piece of tubing drawn at the

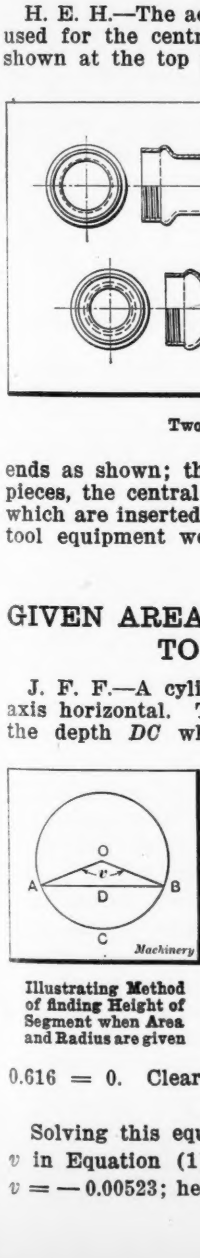


Two Designs for Stud of Bicycle Pedal

ends as shown; that at the bottom, a part made from three pieces, the central part being a piece of straight tubing into which are inserted two formed pieces, one at each end. What tool equipment would be required for making these parts?

GIVEN AREA AND RADIUS OF A SEGMENT TO FIND THE HEIGHT

J. F. F.—A cylindrical tank, 30 inches long, lies with its axis horizontal. The radius OA is 5 inches; what must be the depth DC when the tank contains 231 cubic inches?



Illustrating Method of finding Height of Segment when Area and Radius are given

A.—The area of the segment AOB in the accompanying illustration is $231 \div 30 = 7.7$ square inches; whence, $7.7 = \frac{5^2}{2}(v - \sin v)$, from which:

$$f(v) = v - \sin v - 0.616 = 0 \qquad (1)$$

To find a value for v, substitute in this equation the first three terms of the sine series, obtaining $v - \left(v - \frac{v^3}{6} + \frac{v^5}{120}\right) - 0.616 = 0$. Clearing of fractions, combining, and reducing,

$$v^5 - 20v^3 + 73.92 = 0 \qquad (2)$$

Solving this equation, $v = 1.620 +$. Substituting 1.62 for v in Equation (1), $f(v) = 0.00521$; substituting 1.61 for v, $v = -0.00523$; hence, v lies between 1.61 and 1.62. Tabulating

v	$f(v)$	
1.61	-0.00523	1044
1.62	0.00521	

the results and finding the difference,

$$v = \frac{523}{1044} \times 1 + 161 = 161.501,\text{ or}$$

1.61501 after restoring the decimal point, when $f(v) = 0$. Substituting this value of v in Equation (1), $f(v) = -0.00001$, showing that the value of v as calculated is exact enough for all practical purposes.

$$DC = 5\left(1 - \cos\frac{v}{2}\right) = 5\left(1 - \cos\frac{1.61501}{2}\right) = 1.5435\text{ inch.}$$

J. J.

RULE FOR MEMORIZING FUNCTIONS OF 30, 45 AND 60 DEGREES

E. N. U.—I should like a rule easily remembered for the natural trigonometric functions of 30, 45, and 60 degrees; I mean, of course, when these functions are expressed as surds.

A.—There are several convenient rules for this purpose; the one preferred by the writer is given in Table 1 and, when

TABLE 1. FUNCTIONS OF 30, 45 AND 60 DEGREES

	0 deg.	30 deg.	45 deg.	60 deg.	90 deg.
sin	$\frac{1}{2}\sqrt{0}$	$\frac{1}{2}\sqrt{1}$	$\frac{1}{2}\sqrt{2}$	$\frac{1}{2}\sqrt{3}$	$\frac{1}{2}\sqrt{4}$
cos	$\frac{1}{2}\sqrt{4}$	$\frac{1}{2}\sqrt{3}$	$\frac{1}{2}\sqrt{2}$	$\frac{1}{2}\sqrt{1}$	$\frac{1}{2}\sqrt{0}$
tan	0	$\frac{1}{3}\sqrt{3}$	$\frac{1}{3}\sqrt{3^2}$	$\frac{1}{3}\sqrt{3^3}$	∞
cot	∞	$\frac{1}{3}\sqrt{3^3}$	$\frac{1}{3}\sqrt{3^2}$	$\frac{1}{3}\sqrt{3}$	0

Machinery

once memorized, is not easily forgotten. When these values have been reduced, they take the forms shown in Table 2. If the secant is desired, simply take the reciprocal of the cosine; thus, sec 30 deg. $= \frac{1}{1/2\sqrt{3}} = \frac{2}{\sqrt{3}} = 2/3\sqrt{3}.$ The cosecant is the reciprocal of sine; thus cosec 45 deg. $= \frac{1}{1/2\sqrt{2}} = \frac{2}{\sqrt{2}} = \sqrt{2}.$ It will be noticed that it is necessary to remember only the values for the sines and tangents, since the cosines and cotangents occur in the reverse order,

TABLE 2. VALUES IN TABLE 1 REDUCED

	0 deg.	30 deg.	45 deg.	60 deg.	90 deg.
sin	0	$\frac{1}{2}$	$\frac{1}{2}\sqrt{2}$	$\frac{1}{2}\sqrt{3}$	1
cos	1	$\frac{1}{2}\sqrt{3}$	$\frac{1}{2}\sqrt{2}$	$\frac{1}{2}$	0
tan	0	$\frac{1}{3}\sqrt{3}$	1	$\sqrt{3}$	∞
cot	∞	$\sqrt{3}$	1	$\frac{1}{3}\sqrt{3}$	0

Machinery

being the corresponding functions of the complementary angles. Thus the complement of 0 degrees is 90 degrees; of 30 degrees, 60 degrees; and of 45 degrees, 45 degrees. To ten decimal places, $\sqrt{2} = 1.4142135624-$, and $\sqrt{3} = 1.7320508076-$. J. J.

A GEOMETRIC PROBLEM

S. C. D.—Will you please show me how to find the distance s from the dimensions given?

A.—Referring to the illustration, $AC = \sqrt{30^2 - s^2} = \sqrt{900 - s^2}$, and $BO = \sqrt{400 - s^2}$. From the similar triangles AOC and DOE, $\frac{AC}{OC} = \frac{DE}{OE}$, or:

$$\frac{\sqrt{900 - s^2}}{s} = \frac{10}{x},\text{ or } x = \frac{10s}{\sqrt{900 - s^2}} \qquad (1)$$

Draw DF parallel to CO; then, from the similar triangles BCO and BFD, $BO \div OC = BF \div FD$, or:

$$\frac{\sqrt{400 - s^2}}{s} = \frac{\sqrt{400 - s^2} - 10}{x} \qquad (2)$$

Substituting in Equation (2) the value of x from Equation (1), and clearing of fractions,

$$90{,}000 - 100s^2 = 400{,}000 - 1400s^2 + s^4 - 20(400 - s^2)\sqrt{900 - s^2}$$

from which:

$$s^4 - 1300s^2 + 310{,}000 = 20(400 - s^2)\sqrt{900 - s^2}$$

Squaring, transposing, and combining terms:

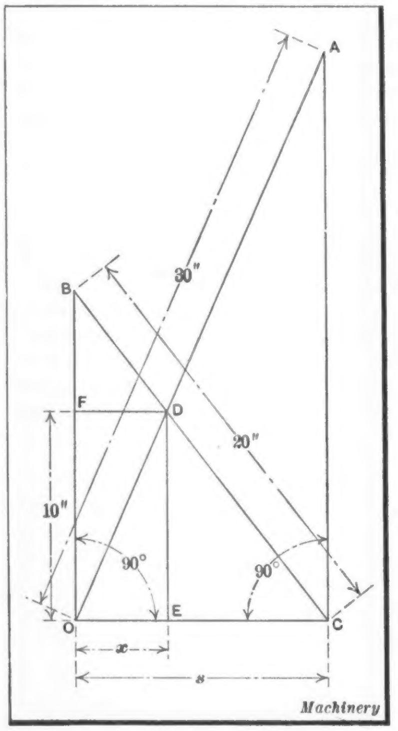
$$s^8 - 2200s^6 + 1{,}630{,}000s^4 - 454{,}000{,}000s^2 + 38{,}500{,}000{,}000 = 0$$

This is an eighth-degree equation; but since all the exponents are divisible by 2, the equation may be reduced to one of the fourth degree and the coefficients simplified by substituting $10\sqrt{y}$ for s. The equation then becomes:

$$y^4 - 22y^3 + 163y^2 - 454y + 385 = 0$$

Solving this equation, preferably by Horner's method, $y = 1.5212$; hence:

$$s = 10\sqrt{y} = \sqrt{100y} = \sqrt{100 \times 1.5212} = \sqrt{152.12} = 12.334 \text{ inches}$$



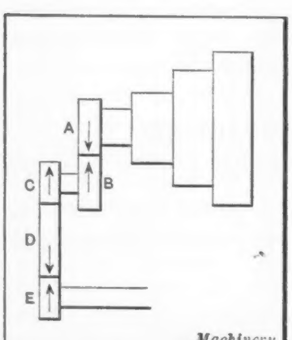
Illustrating a Geometric Problem

If the angles AOC and BCO are also desired, substitute the value of s in Equation (1) and obtain $x = 4.5101$ inches. Then, $\tan AOC = \frac{10}{4.5101}$; from which $AOC = 65$ degrees 43 minutes 27 seconds. $CE = s - x = 12.334 - 4.5101 = 7.8239$. Therefore, $\tan BCO = \frac{10}{7.8239}$; from which $BCO = 51$ degrees 57 minutes 39 seconds. J. J.

CALCULATING CHANGE-GEARS FOR 4.5-MILLIMETER PITCH

H. S. R.—The lead-screw of my lathe has five threads per inch, and the fixed gear on the stud has twice as many teeth as the gear it meshes with on the spindle. I wish to cut a thread having a pitch of 4.5 millimeters; what change-gears must I use if the variation is not to exceed 0.01 millimeter?

A.—It is assumed that your lathe is simple geared and that the arrangement of the gears is as shown in the illustration. It is first necessary to express the pitch of the thread to be cut and the pitch of the lead-screw in the same units; this may be done by reducing the 4.5 millimeters to inches or the pitch of the lead-screw to millimeters; the writer prefers the former. Since 1 millimeter = 0.03937 inch, 4.5 millimeters = $0.03937 \times 4.5 = 0.177165$ inch. The limit of variation being 0.01 millimeter, the pitch of the thread must be greater than $4.5 - 0.005$ and less than $4.5 + 0.005$ millimeters. But 0.005 millimeter = 0.000197 inch; hence the pitch of the thread must be greater than $0.177165 - 0.000197 = 0.1770$ inch and less than $0.177165 + 0.000197 = 0.1774$ inch, expressed to the nearest 0.0001 inch. The pitch of the lead-screw is $1 \div 5 = 0.2$ inch.



Change-gears for Thread Cutting

If gears A, B, C and E have the same number of teeth, one spindle turn will produce one turn of the lead-screw, and the tool will advance 0.2 inch. Assuming for the present that gears A and B have the same number of teeth, gear C must be smaller than gear E, since the pitch of the screw to be cut is less than that of the lead-screw, the ratio being $\frac{0.177165}{0.2} = \frac{0.885825}{1} = \frac{35433}{40000}$. Expressing this last fraction as a continued fraction (see MACHINERY for July, 1916, page 989), the following convergents are obtained: $\frac{0}{1}, \frac{1}{1}, \frac{7}{8}, \frac{8}{9}, \frac{31}{35}, \frac{225}{254}$. The last fraction is very accurate, being equal to 0.885826; that is, when the spindle makes one turn, the lead-screw makes 0.885826 turn, and the tool advances $0.885826 \times 0.2 = 0.1771652$ inch. However, the terms of this fraction are too large; hence, trying the preceding one, $\frac{31}{35} = 0.885714$, and $0.885714 \times 0.2 = 0.17714+$, a value that is within the specified limits. Since gear B has twice as many teeth as gear A, gear C must have $31 \times 2 = 62$ teeth, and gear E must have 35 teeth. J. J.

HELIX WITH VARIABLE PITCH

M. A.—I wish to cut a helical groove in a cylinder 2.10 meters long, having a diameter of 0.25 meter. The helix has a variable pitch, being 3.70 meters at the beginning and 2.25 meters at the end of one turn. How can I lay out the developed helix, and what is the ordinate corresponding to a point on the helix 1.25 meter from the beginning?

A.—In the illustration, $ABCD$ and the circle represent two projections of the cylinder and $A_1B_1C_1D_1$ represents the development of the cylinder, the length A_1D_1 being $3.1416 \times 0.25 = 0.7854$ meter. It will be more convenient to express all dimensions in centimeters. This being understood, the length of the cylinder is 210, its diameter is 25, the circumference A_1D_1 is 78.54, the pitch at the beginning (the initial pitch) is 370, and the pitch at the end (the final pitch) is 225. Assuming that the pitch varies uniformly from 370 to 225, a point on the helix at the end of one turn will be half way between 370 and 225 and situated on the line C_1D_1 produced. In other words, the developed helix will intersect C_1D_1 at a point distant $\frac{370 + 225}{2} = 297.5$ from D_1. Designate this point by H (it is omitted from the diagram for lack of space); then $D_1H = 297.5$, which is the pitch at the point H. The pitch at H is also equal to $370 - \frac{370 - 225}{2} = 370 - 72.5 = 297.5$, as before. The pitch at any intermediate point P will be proportional to the distance $EP = x$; that is, the pitch at P is $370 - 72.5 \times \frac{x}{78.54}$. The distance $A_1E = y$ is equal to the pitch at P multiplied by $\frac{x}{78.54}$. Hence, the relation between y and x is expressed by the equation:

$$y = \left(370 - 72.5 \times \frac{x}{78.54}\right)\frac{x}{78.54} = 4.710976x - 0.011753x^2$$

It is to be noted that if the pitch were uniform and equal to 297.5, the developed helix would be the right line A_1F, which cuts C_1D_1 at the point H, 297.5 centimeters from D_1. Since the pitch is variable, the developed helix cannot be a right line, but a curve, represented by line A_1PG. To draw this curve, divide the circle, representing the bottom view of the cylinder, into any convenient number of equal parts, say 16, and divide A_1D_1 into the same number of equal parts. The arc $0\text{–}1 = 1\text{–}2 = 0_1\text{–}1_1 = 1_1\text{–}2_1 = \text{etc.} = \frac{78.54}{16} = 4.90875$. $0_1\text{–}2_1$ evidently equals 2×4.90875; $0_1\text{–}3_1 = 3 \times 4.90875$; etc. Substituting these values for x in the foregoing equation, the corresponding values of y are found, which are the points 1, 2, 3, etc., on the curve A_1PG, and through which the curve

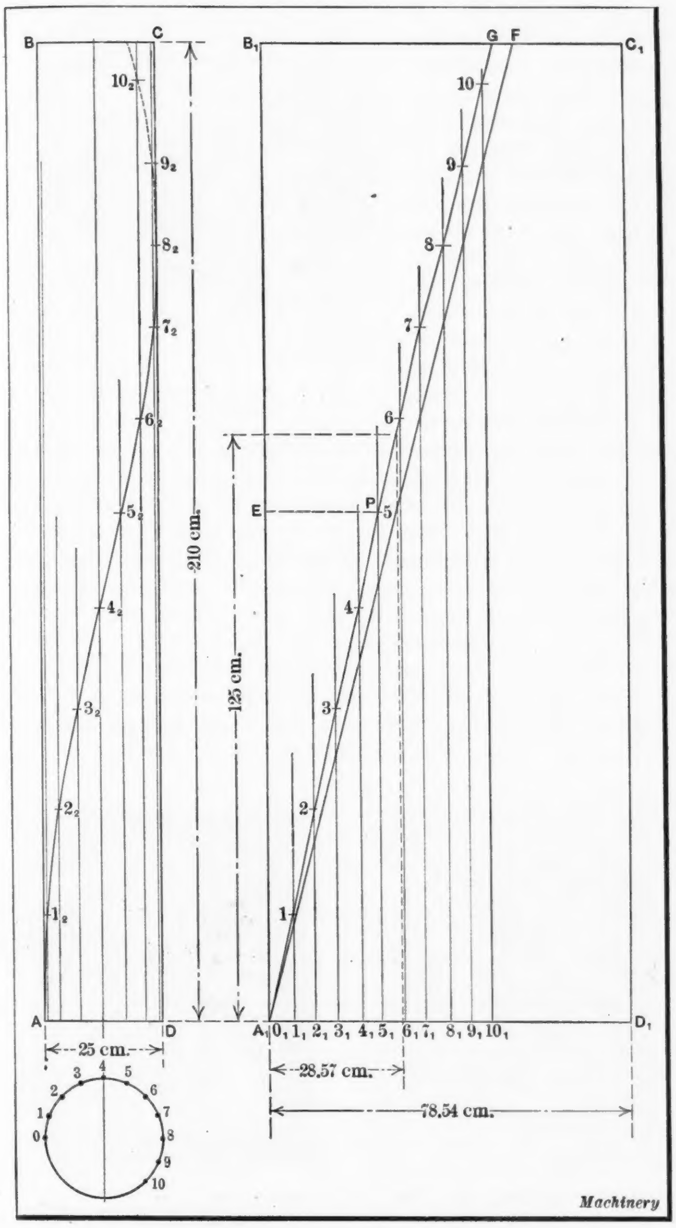


Diagram of Helix with Variable Pitch

is traced. To find the value of x for any particular value of y, substitute the value of y in last equation and solve for x; for instance, if $y = 125$, as shown in the illustration, $x = 28.57$. Similarly, the value of x for $y = 210$ is $51.09 = B_1G$.

To draw the projection of the helix on the cylinder, draw vertical lines through the points 1, 2, 3, etc., of the circle and horizontal lines through the points 1, 2, 3, etc., of the curve A_1PG; they intersect in 1_2, 2_2, 3_2, etc., through which the curve may be traced as shown. When applying the formula to calculate the various values of y, first substitute the value of $x = 0_1\text{–}1_1 = 4.90875$, obtaining $y = 23.1251 - 0.2832 = 22.8419$. For $x = 0_1\text{–}2_1 = 2 \times 0_1\text{–}1_1$, $y = 23.1251 \times 2 - 0.2832 \times 2^2$; for $x = 0_1\text{–}3_1 = 3 \times 0_1\text{–}1_1$, $y = 23.1251 \times 3 - 0.2832 \times 3^2$; etc. This method of calculating values of y is much easier than direct substitution of x, and is one of the reasons for dividing the circle into equal parts. Since the equation giving the value of y is of the second degree between two variables, it is the equation of a conic section. Applying the usual test, the curve A_1PG is found to be an arc of a parabola. Note that when 78.54 is substituted for x, $y = 297.5$, as it should. J. J.

* * *

CORRECTION

An error appeared in the article "Economical Production of Accurate Hardened Gears" in the December number. The sentence "The hole is ground to within 0.0001 inch of finish size, this amount being allowed for grinding after the gear is hardened," should read, "The hole is ground to within 0.001 inch of finish size," etc.

MALLEABLE IRON AND ITS USES

At a meeting of the American Iron and Steel Institute an article on malleable iron and its uses was presented by Henry F. Pope. He said that iron as it is run from the furnace and poured into the molds in the process of making malleable iron castings is not malleable at all, but is extremely hard and brittle. When broken, it shows a white fracture. But this brittle iron is of such composition that when subjected to the proper annealing heat for the requisite length of time, it is transformed into an iron with entirely different physical qualities. After annealing, instead of showing a white fracture, it shows a black one, giving it the name of "black heart." This distinguishes the malleable iron made in this country from that made in Europe, which has a steely fracture, due to the fact that the carbon is almost entirely removed by oxidation in the annealing process. The black fracture of American iron is due to the fact that in the annealing process the carbon, which in the original casting was all combined, has been separated out by decarbonization and is now found as free carbon or graphite of non-crystalline form deposited between the molecules of the iron. This form of carbon is called "temper carbon." The presence of a large amount of temper carbon gives the material its black appearance. The iron itself, therefore, is left almost entirely free from any combination with carbon and possesses the malleable quality of wrought iron. It can be bent without fracture and withstands great shock and stress without breaking. It has the superiority of wrought iron in the respect of malleability without the sometimes objectionable fibrous structure of that material. Someone will say, "Why use malleable iron any more when steel castings may be had?" That is a pertinent question, for great strides have been made in steel casting production and certain castings have been changed from malleable iron to steel with improved results; but there are several reasons why steel will never displace malleable iron for a multitude of articles. In the first place, in most cases, if the steel could be produced in the form and section of the malleable casting, it would be more expensive and no better; for, while the tensile strength of malleable iron is somewhat below that of soft steel, its elastic limit is just as high, which means that it will stand just as severe service as the steel. Years ago malleable iron began to be used advantageously for agricultural implements, all sorts of farm tools, wagons and carriages, harnesses, stoves, pipe fittings, and for many other purposes. Later the railroads began to use it, for many parts of cars could be made lighter and less subject to fracture by the substitution of malleable for gray iron. The railroads also used it in places where the iron is exposed to the corrosive action of the weather, for malleable iron is as non-corrosive as any of the iron products and much more so than steel. More recently malleable iron has become popular in automobile construction. Other good qualities are its high permeability and its low magnetic hysteresis, qualities which render it desirable for certain electrical machinery.

* * *

EDITORIAL CONFERENCE OF ASSOCIATED BUSINESS PAPERS

At the Editorial Conference of the Associated Business Papers, a society representing more than one hundred and fifty trade and technical journals, held in Washington, December 13, the subject of the excess profits law was explained to the editors by Internal Revenue Commissioner Roper, who mentioned that it was intended to make the tax burden as light as possible under the law. For partnerships and individuals, reasonable salaries would be allowed as reductions from profits before determining the taxable residue. Competent revenue officers will be sent early in the year to different parts of the country to aid in the making out of income tax returns. An interesting feature of the meeting was the address by Anna Howard Shaw, chairman of the Women's Section of the Council of National Defense, who urged the editors to use the influence of their journals to induce technical schools to train women for engineering work.

DIE-CASTING DIES

Some remarkable die-casting dies recently made by the Marf Machine Co., New York City, are shown in the accompanying illustrations. Fig. 1 shows the castings that are produced, which are made of pure tin. The dies used in producing casting *A* are illustrated by Figs. 2 and 3.

Fig. 2 shows the lower member of the die in position for the casting to be ejected. The arms of casting *A*, Fig. 1, serve as tubes, and the holes are formed by steel cores, which must be withdrawn from the casting before it can be ejected. These cores are withdrawn by operating levers turning shafts having teeth that engage with racks cut on the rods upon which the moving parts slide. There are seven operating levers, and six of these must be turned their entire movement before the seventh one, which ejects the casting, can be operated. This lever raises a plate on which there are twelve vertical pins; six of these are locking pins, and the others are ejectors. The locking pins engage with holes in the moving parts of the die, so that these parts must be placed in the correct position by the levers mentioned before the final lever can be turned; this makes an effective locking device. Several of these locking pins may be seen at *A*, *B* and *C*, Fig. 2. The ejector pins, which raise the casting, are indicated by *D* and *E*. A part of the die itself, *F*, rises at the last operation and assists in ejecting the casting. Instead of the usual method of cutting grooves on the shafts for oiling, there are drilled spots that form oil-pockets for conveying the oil to the bearings. Fig. 3 shows the upper member of the die that was made from a solid block of steel and has no moving parts. The hot metal is forced in at hole *A*, into which the sprue cutter extends. The sprue cutter is shown at *G* in Fig. 2. The upper member is guided by pins.

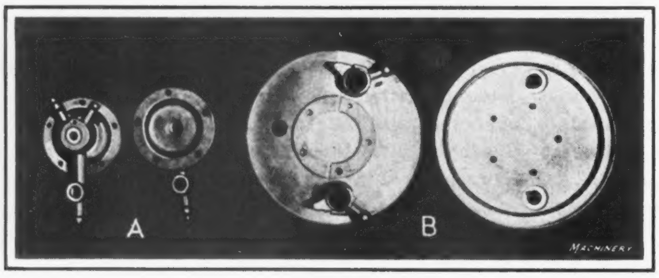


Fig. 1. Castings that were formed in Dies Illustrated

This die is for use on a hand-operated machine, but can also be used on machines operated by steam or compressed air. The total weight of the die is about 500 pounds. There is a water jacket in the die, surrounding the casting, for cooling purposes. The die is blown out by compressed air after each use. It is estimated that one hundred castings can be made per hour with three men operating the die-casting machine.

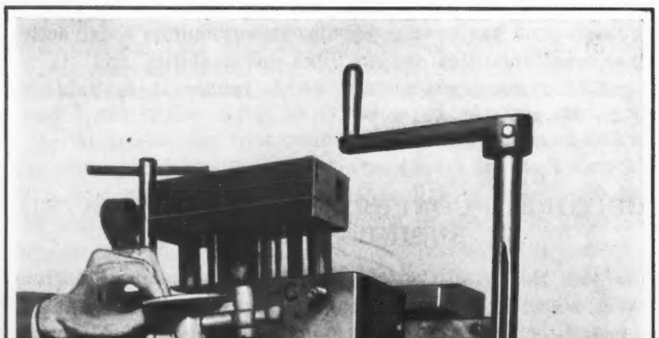


Fig. 2. Lower Member of Die for Casting A, Fig. 1

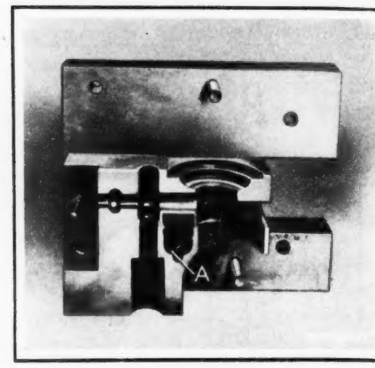


Fig. 3. Upper Member of Die for Casting A, Fig. 1

The die used for casting *B*, Fig. 1, is illustrated in Figs. 4 and 5. The die is shown in Fig. 4 in position for removing the casting. An interesting feature of this die is that, in order to get the form of the under-cut beneath the arms, it is necessary to have two loose pieces that remain on the casting when it is removed. One of these is seen on the casting at *A*, while *B* shows it replaced. After these pieces are again in position, the operating lever is turned, and through the medium of the teeth on the shaft, and slanting teeth on the slides of the die, these slides are brought forward, holding in place the loose pieces and completing the shape of the die, also forcing in the round cores that make the holes in the arms of the casting. There are five brass, tapped, hexagon inserts cast in the piece, which are held in position by the pins shown. The metal is forced in through hole *C*. The sprue cutter is illustrated at *A*, Fig. 5. The method of forming the under side of the casting is shown in Fig. 5.

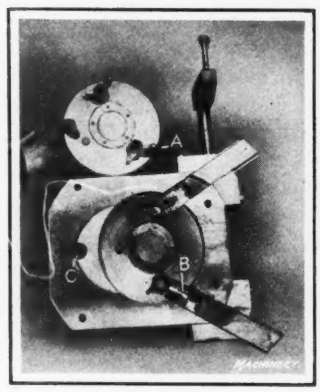


Fig. 4. Lower Member of Die for Casting B, Fig. 1

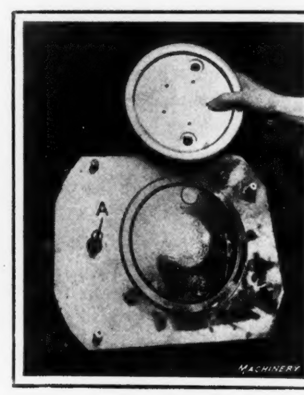


Fig. 5. Upper Member of Die for Casting B, Fig. 1

* * *

IMPORTANT SAVING BY NEW METHODS OF HANDLING FREIGHT

Less-than-carload freight shipped from Philadelphia, under the new "shipping day" or "sailing date" plan, is moving to destination with more than three times the average speed achieved under the old method of handling. Observations of actual car movements from Philadelphia to a large number of points on the Pennsylvania lines, both east and west of Pittsburg, the results of which have just been tabulated, show that, from the placing of the freight in the car until it reaches its destination, the average speed of movement has been more than tripled. For instance, where the average time in transit was formerly three days, it is now less than one day, and where it was formerly six days, it is now less than two days. In addition to the benefit resulting to shippers from greater speed in transit, the "shipping day" plan, as hitherto announced, by saving the use of nearly 100 cars per day in handling less-than-carload freight from Philadelphia, is helping to increase the car supply for other purposes.

This information given out by the Pennsylvania Railroad verifies the contention that American railroads were inefficiently managed as regards their car equipment and system of handling both freight and passenger traffic. It would be well if the war would teach those responsible for the management of American railroads that they have a great deal to learn before the roads will be run efficiently.

WILL HIGH PRICES MAKE TWO CUTS DO WHAT TEN DID BEFORE?

BY D. M. PERRILL [1]

The conversation had been about tooling and cuts taken with engine lathes in the average manufacturing plant. Possibly it was the ability to see the silver lining in any cloud that caused the visitor at a large machine tool plant to say that he believed the present high prices of machine tools would force manufacturers to obtain the best possible production from their machine tools; certainly this has not been done in the past.

For instance, a lathe company found it necessary to place one of its demonstrators, for a few months, in a plant that was turning out work for it, to test the work and see that it came up to the required standard. At the end of this time, the writer visited the plant and was surprised to see the way in which the lathe work was being done. In explaining the situation, the demonstrator said he would have been only too glad to assist, but was helpless in the matter, as he had no authority over the operators or methods used in turning out the work, and so could only make suggestions. While there had never been any particular objection to his showing the men the proper cuts and feeds to use in turning out work, when he stopped watching an operation, the operator immediately slipped back to the old methods, and did in ten cuts what should have been done in about two or at the most, three. In this case the fault was purely a matter of depth of cut, feeds, and speeds, but when we come to tooling, examples can be found in wholesale numbers. These faults are not confined to the use of engine lathes; failures to secure the proper results from every kind of machine tool will be found.

It is the belief of the writer that this is a form of lethargy on the part of the operator, foreman, and superintendent. For the two latter it is a question simply of what point they shall apply their attention to, and since the work is turned out under the present methods, they are willing to let it drift. If the present prices of machine tools will cause the operators, foremen, and superintendents to concentrate their attention on proper methods of obtaining the greatest production from every machine tool, the silver lining seen in the cloud of high prices by the visitor will not only be pure metal but a lot of manufacturers will cash in on it at their banks.

In the meantime there is no reason why every machine shop cannot cash in on some of the silver lining, even if they do not have to buy additional machine tools at the new prices. With the sales limit purely a matter of production capacity in every metal-working shop, anything that will increase that capacity is naturally of greatest interest. The first step is for each shop to find out what is possible in the way of metal reduction, remembering that these things are most profitable when applied to standardized work and quantity production. And by increasing its production, a shop assists in meeting the greater demand, in offsetting the effect of the diminishing labor supply, and in helping the government through the present crisis. It is like buying Liberty Bonds; you are performing a helping act, but really no one is helped quite as much as yourself.

* * *

The fire waste in the United States is appalling, being considerably more than $200,000,000 yearly. Some fires have their origin in conditions that could not be foreseen, but by far the greater part could have been avoided by taking the simple precautions that experience has shown to be effective. When one visits a manufacturing plant consisting of wooden buildings without sprinkler equipment or the more primitive fire-fighting apparatus, and sees waste piled against wooden partitions, floors littered with excelsior, work-benches set against the walls with greasy boxes and litter piled beneath, he feels that the foolkiller is on his way and will arrive sooner or later. A clean and orderly shop not only favors production but insures against accidents and fires. The insurance costs comparatively little and is worth many times the price.

[1] Address: 346 Probasco Ave., Cincinnati, Ohio

WOMEN WORKERS IN THE SHOP

BY DONALD A. BAKER [1]

There has been much discussion of late as to the advantages and disadvantages of employing women to replace men in the mechanical industries. As the writer has had considerable to do with women in munition factories both here and in Canada, it may be that his experience will be of value to others.

While on general principles one dislikes the thought of employing women on work that has been done entirely by men, industrial conditions seem to warrant such employment at the present time; and as the conditions have been forced on us, we must make the best of them. Disregarding sex and looking at the problem from a purely economic or commercial standpoint, the employment of women in mechanical lines has many advantages. When proper care is exercised in assigning work that is fitted to a woman's strength, when the hours of labor are kept well within reason, and other things are equal, there is no more reason why women should not be employed than in other lines. Actually, a great deal of the work on which they can be employed in machine shops is lighter and less monotonous than many occupations that have fallen to their lot in the past.

The fact that women, as a rule, are not naturally of a mechanical turn of mind is, strange to say, one of the best reasons for employing them on repetition work, and especially for running machines of a more or less delicate and complicated construction that require some adjustment from time to time. This fact is illustrated by the experience of a Canadian fuse factory. When men were employed on a number of semi-automatic machines it was almost impossible to keep the machines in repair. In spite of everything that could be done, the men insisted upon trying to make their own adjustments and minor repairs. Not being mechanics, they were not provided with the proper tools for this work, and so would use anything they could lay their hands on. Fuse bodies and monkey-wrenches were used for hammers and pieces of pipe, old files, etc., were jammed into the mechanism of the machines. Bearings were tightened until they ran hot and scored. Gibs were tightened until they bound and refused to work or were loosened until the slides ran out of true and spoiled work. Sight-feed oil-cups were stolen and presumably sold for junk. As soon as the men were replaced with women, the repair of the machines became normal. Besides, production began to increase as the girls acquired the necessary skill, until in a few days their production was much greater than that of the men.

These results were due to two things: the misplaced mechanical initiative on the part of the men operators, and the entire lack of this faculty on the part of the women operators. The men would not give the mechanics or toolmakers a proper chance to keep the machines in repair, while the women, when anything went wrong, instead of trying to fix it themselves, were only too glad of the chance to sit back and take a rest while a competent man did the work.

On other classes of work it was found that, when properly managed and disciplined, the women operators acquired greater skill and speed than men employed on similar work. This was especially true of work of a light nature that required speed and accuracy of handling. This is due, in part, to the fact that women's hands and minds are practically untrained to systematic motion, so that they more readily lend themselves to instruction, and when once taught the proper rotation of movements required to do a given task in the least time, they stick to these movements and soon become efficient operators. Men, on the other hand, especially if left to themselves long enough to acquire a wrong method, are more inclined to be stubborn and assume that because the way they are doing the work seems easy to them their way is best, without stopping to analyze it.

As this is the case, if women must be employed, they should be paid equal wages for equal work. Their strength must not be unduly taxed, suitable convenience must be provided for them, and the hours of labor restricted. In return, they will give higher production and lower operating costs.

[1] Address: Care of Anderson Forge Machine Co., Detroit, Mich.

INSPECTION OF SCREW GAGES FOR MUNITIONS OF WAR[1]

MEASUREMENT OF PITCH AND OF FULL, EFFECTIVE AND CORE DIAMETERS

UNTIL recently, the matter of accuracy of pitch of screw gages has been almost entirely neglected, attention in the inspection of such gages being given only to the correctness of the ruling diameters of the thread; that is to the core[2], effective and full diameters.

This measurement must be made with great exactness, since any error in the pitch of a plug screw requires that the pitch diameter be reduced by about twice the amount, in order that the gage may function in an identical way to a similar gage with the proper pitch. In a ring screw gage, the pitch diameter must be increased in a corresponding manner. Within the last two years the question of pitch has forced itself to the front because of the accuracy required in the screw gages used on munitions work, where the allowances for incorrectness of workmanship of the product are very small, being a matter of only a few thousandths of an inch, as a rule, especially in fuse work. For example, a very important gage used on British shells is that which checks the screw in the nose, into which the fuse is fixed. This is a "go" or "low" plug gage, and the tolerances for the accuracy of the gage are as follows:

Tolerance	+ 0.0003 inch	Range
	— 0.0006 inch	0.0009 inch

If the error in the pitch = 0	Normal effective diameter: 1.9513 inch
	Maximum effective diameter: 1.9516 inch
	Minimum effective diameter: 1.9507 inch

Thus, for each 0.0001 inch error in the pitch of the plug gage, the gage-maker reduces his "high" limit of the tolerance for the pitch diameter by 0.0002; and finally, if the error amounts to 0.00045, he has no tolerance left on the pitch diameter, but must make it to the low limit. In practice, an error in the pitch of more than 0.0002 inch ought not to be exceeded, in order to leave sufficient margin of tolerance for the effective diameter, to meet workshop requirements.

TABLE 1. LIMITS OF EFFECTIVE DIAMETER

If the Error in the Pitch is	Limits of Effective Diameter	
	High	Low
± 0.0001 inch	1.9514 inch	1.9507 inch
± 0.0002 inch	1.9512 inch	1.9507 inch
± 0.0003 inch	1.9510 inch	1.9507 inch
± 0.0004 inch	1.9508 inch	1.9507 inch
± 0.00045 inch	1.9507 inch	1.9507 inch

Machinery

Errors in the pitch are of two kinds: (1) Variable error; that where the distance from thread to thread varies in an erratic manner. This is generally due to distortion after hardening (through want of proper seasoning, to permit the molecular structure of the steel to come to a stable form. The great demand for gages during the war has prevented sufficient time being given to seasoning, and the distortion that arises affects not only the pitch but also the roundness of the screw), or to faulty adjustment of the thrust bearing of the lead-screw of the lathe or grinding machine. (2) Progressive, or gradually increasing, error is due to a bad lead-screw or else to the lap used for finishing the gage not having an identical pitch to that of the lead-screw on the machine in which the gage was made. The latter cause of bad pitch shows the necessity of making both the lap and gage on the same lathe or grinding machine. In practice, both kinds of error in pitch usually occur in combination; thus a variable error is the resultant, since the positive progressive error is reduced or increased in places by variable errors of the opposite or same sign. The maximum error in pitch between thread and thread, or over a number of threads, is the ruling error in determining the reduction to be made in the effective diameter. Until recently, it was a common practice to stipulate the maximum error in pitch permissible over a given length of thread, such as one-half inch or one inch. This is an incorrect manner of specifying the correctness of the pitch, since thereby an assumption is made that the error is of the progressive type, whereas, as already indicated, it is usually not so. In fact, with the common form of variable error in pitch, cases may happen where a positive error between a thread or two is annulled a little farther on by a similar negative error, and over one-half inch or one inch the resultant error would measure as zero. There exist a number of devices to measure the pitch, based on the idea of measuring over a given number of threads. For example, sometimes two blocks, similar to Johansson blocks, are used with their ends ground to a triangular form of the same included angle as that of the screw to be checked; between these are placed Johansson blocks to give the correct distance corresponding to the number of threads over which the measurement is to be made. The piece is then inserted into the screw and the bearing of the points on the slopes of the screw observed under a magnifying glass; if the bearing is not satisfactory, the Johansson blocks are changed for others differing by the number of tenths of a thousandth of an inch considered convenient to give the desired bearing. The objection to this method of measuring the pitch is the personal equation brought in by the observer having to watch by eye for the proper bearing of the points in the thread, and, further, the fact that the points cannot be brought near enough together to measure between adjacent threads, because the blocks have to be of a certain minimum thickness. Another instrument has two V-pointed pieces, one of which is fixed and the other movable, parallel to the first. The movable point is connected to a long lever arm which moves over a scale graduated to give readings in thousandths of an inch. The screw is inserted between centers and gradually raised to the V-points, being turned on its axis, meanwhile, until both V-points bear evenly in the thread. The bearing is observed under a magnifying glass, assisted by a light fixed behind the screw. This instrument does not give readings reliable to more than 0.0002 or 0.0003 inch, and, further, the pitch is measured on the fixed distance of one-half inch. There are numerous other devices of a similar nature, which all suffer from the fundamental defects noted in the instruments described. There are a few machines to measure the pitch from thread to thread, but they have the defect that the accuracy of the operation depends on the care taken by the user.

In England an ingenious method has been used by Mr. Vidal in his patented pitch measuring machine. The V-point is substituted by a ball, so that it can bear evenly in the thread whatever the inclination of the spindle to which it is fixed, and the ball is split, with a lamina of mica interposed to insulate the two portions. Electric circuits are made between the halves of the ball and the screw, and will close only when the ball is touching the slope of the thread on both sides. The spindle with the ball is connected to a longitudinal carrier of a triangular truss form with a spring arranged to press it toward the screw, and so keep the ball in continual light contact with the thread. The adjustment given by the spring is so delicate that the carrier can be blown away from contact by the breath. The carrier is attached to a micrometer head. To obtain a perfect contact with the screw, the latter and the ball must be quite clean and free from all grease, since otherwise the electric circuit will not close. This incidental condition of working gives a further guarantee of accuracy, because the operator of the instrument knows that

[1] Abstract of a pamphlet by H. J. Bingham Powell, the inspector in charge of the department of gages and standards of the British Ministry of Munitions of War in the United States, 165 Broadway, New York City. Published by permission of the author.

[2] In this abstract, the terms employed for the ruling diameters of a screw are those adopted by the Engineering Standards Committee of Great Britain, and are as follows: "full" (or major) diameter; "effective" (or mean) diameter; "core" (or minor) diameter, corresponding, respectively, to the terms "outside," "pitch," and "root" diameters, usual in the United States.

he is obtaining a true contact on the thread, without a film of oil intervening.

A very good pitch measuring machine is used by the National Physical Laboratory of the Department of the British Government in charge of the inspection of gages. The screw is mounted on the centers of a stiff bed which carries a saddle sliding parallel to the line of centers. The feeler carried by the saddle takes the form of a small spherical ball at the end of a bent lever. The ball is held pressed into the threads of the screw by a light spring, and as the saddle is traversed along, the ball moves to and fro, always remaining in contact with the screw. The ball is too large in diameter to reach the bottom of the thread. In its motion it slides down one flank of the thread until it is arrested by contact with the opposite flank, when it immediately begins to move up this flank; this change of motion is very sharply defined. By noting on the micrometer screw the positions of the slider at which these changes of motion take place, we clearly have a means of measuring the pitch of the screw. To effect this, a mirror is attached to the arm carrying the small sphere and rotates backward and forward as the arm moves. A spot of light reflected from the mirror onto a scale moves in one direction, then stops and moves back; after a time, its motion is again reversed, and so on. The sharp reversals caused by the point of contact of the sphere passing from one flank of the screw to the opposite flank are clearly defined, and by their means an accurate measure of the pitch is obtained.

By a suitable arrangement of the "feeler," the pitch of ring screw gages can be measured, the gages being fixed on a faceplate at the end of the instrument. Fig. 1 shows a machine used by the gage department of the British Ministry in the United States. It consists of a base A in the form of a surface plate supported at the corners by screwed legs B for leveling purposes. At the back of the base are two cast-iron brackets C with double V-ways of hard steel D to carry balls. On the bracket runs a "carriage" E made in the form of a long, narrow plate of suitable thickness for stiffness, and with the ends carrying V-ways F corresponding to those on the brackets. The carriage is pushed to and fro by a micrometer head G bearing on a round-ended spindle H screwed into the carriage, the spindle being maintained in contact with the micrometer spindle by a light weight I on cords passing over hooks K. The micrometer head carries a large aluminum disk L divided into 250 divisions on the periphery, each spacing being 1/10 inch long, so it is easy to read to ten-thousandths of an inch and even to a fifth of that amount, if a good micrometer is acquired. On the axis of the carriage is a V-opening M, against which the ball-ended spindle N rests (at a point about two-fifths of its length from the ball), in a slightly inclined position (about 7 degrees with the vertical). The lower end of the spindle is restrained from side movement by parallel guides O ground in the foot of an L-piece fastened to the under side of the carriage. The opening in the guides is only about 0.00015 inch wider than the diameter of the spindle; thus, although the latter has entire freedom of movement in the vertical plane containing the axis of the carriage and the screw gage, it has none in a plane at right angles. The spindle is of smaller diameter in the portion P projecting above the carriage, and at the top can

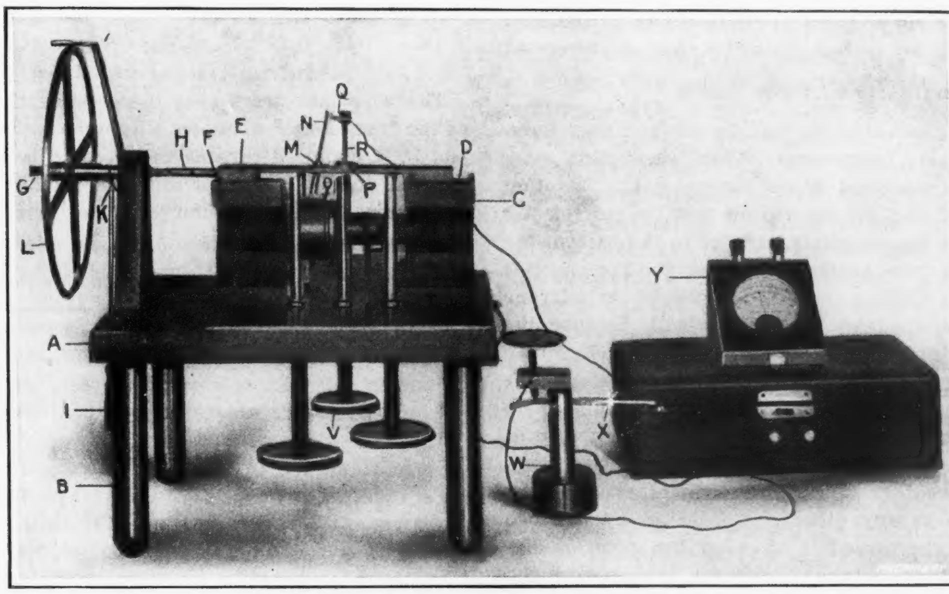


Fig. 1. Bingham Powell Pitch Machine

be brought to bear, by moving the carriage to and fro, into contact with a knife-edged electric contact Q carried on a small post R fixed into the carriage. The screw gage S is carried on V-blocks and held from longitudinal movement by a stout rubber band passing through hooks in the base of the machine T. The blocks have ways at the sides, to slide on carefully adjusted posts, fixed in the base of the machine, so that the axis of the gage, carriage and ball-ended spindle are always in the same vertical plane. The V-blocks can be slowly raised or lowered by fine screw motions at V. It is most important that the top of the threads of the gage should be truly horizontal; this is obtained by using an electric level W in the form of an adjustable arm X carried on a post whose base rests on the surface plate or base of the machine.

The level is brought over one end of the screw gage and the latter is then slowly raised by screwing up the V-block until the arm of the level just lowers at the back from contact with its adjustment screw; this is shown by an electric circuit being broken through a galvanometer Y. Then the level is moved along to the other end of the screw, which is similarly raised to the proper height by the V-block at that end. The ball-ended spindle is afterward placed into the first thread of the screw, and the carriage slowly moved to the left or right until the top of the spindle (which swings about and slides through the V-support) just touches the knife-edge, as shown by the electric circuit being completed through the galvanometer. The reading of the micrometer is noted. The spindle is raised and inserted into the second thread and the carriage again moved until electric contact with the knife-edge is obtained. The difference of readings of the micrometer will give the pitch between the first and second threads; and so on for the succeeding threads. The ball point and gage must be free from oil or dirt, to obtain an electric circuit, and thus an additional factor in favor of accuracy is obtained.

To take the pitch of ring screw gages, a special appliance has been designated in which the mold is made and afterward placed into the V-blocks of the machine and treated as a plug screw gage. This appliance has centers so that it may be also used to carry the casts in the projection apparatus for throwing an enlarged (fifty times) image of the thread onto a screen, to see that the angle of the slopes and the rounding at the crest and root are correct. It is useless to take a cast filling up the ring, as it is usually spoiled in being withdrawn, and, further, as the cast has to be unscrewed to do this, the material, if plastic, will take the form and pitch of the last thread, and so be worthless. Thus only a small segment of the thread should be molded. In the ordinary way it is troublesome to do this; also, as usually obtained, the cast has no centers or reference axis parallel to the thread for setting up in a pitch or other measuring machine. As the gage is made against a faceplate, the cast should be carried in an apparatus with its axis exactly at right angles to the face of the gage in order to be able to use it in a pitch machine. The apparatus used is shown in Fig. 2, and consists of a small square base of plate steel with the surfaces ground true. Into the plate is screwed exactly at right angles a spindle with an inclined wedged shape slot at the bottom. The gage is placed

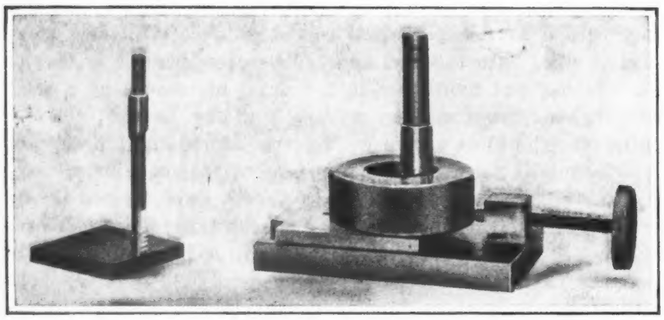


Fig. 2. Apparatus to take True Casts of Ring Screw Gages

on the plate and held against the slot of the spindle by a clamp. The sleeve on the spindle is brought down, so that the slot is not open more than the proper length where the screw bears. A melted composition of 7 per cent graphite and 93 per cent sulphur is poured into the slot. When set, the clamp is removed and the gage carefully drawn away from the spindle, over the baseplate. A perfect cast of the thread remains in the spindle, and it cannot fall out, as the smaller opening of the wedge is below when the spindle is placed in the pitch machine. The cast of the thread as taken is absolutely parallel to the spindle and at right angles to the baseplate, and so is in the correct condition for measurement.

Measuring Plug Screw Gages

The usual way of measuring the full diameter of plug screw gages is by an ordinary micrometer. This is sufficient, since a machine, such as described below for checking the other diameters, is not suitable, for the reason that the micrometer spindle face may not be absolutely parallel to the face of the screw, and so give a false reading; whereas for the effective and core diameters, a slight want of squareness of the micrometer face will not appreciably alter the result, because the bearing is on a wire or triangular piece, and is therefore self-adjusting. However, in measuring the full diameter, care must be taken to see that this is done on several diameters at right angles to each other, to note distortion, and also at different points along the screw for taper. The effective diameter is measured by either thread micrometers or wires or, preferably, by both, as any difference observed by the two methods shows that the thread is of either bad form or else is "staggered" (inclined to one side along the axis of the screw); but these defects are better seen in a projection apparatus. The thread micrometer should never be used alone, because it bears only on protruding points on the slopes of the thread. Also, the point of a micrometer wears rapidly, and it is difficult to check it accurately, the V-pieces supplied by makers being generally not very reliable.

Screw measuring machines have been devised where the thread micrometer principle is used. One of these has a true surface base and, suspended above, a micrometer head with the spindle ground at the point to the angle of the thread (55 degrees for the Whitworth thread, 60 degrees for the metric and U. S. standard thread, and 47½ degrees for the British Association thread). On the base rest little blocks, with the tops ground to a V-edge, of the same angle. The screw is seated on two of these blocks, placed as near together as possible, and then the micrometer point brought down to bear, the "feel" being obtained by moving the screw to and fro on the blocks. The objection to this instrument is that the bearing on the blocks must be at a number of threads apart, because of the thickness of the blocks, and so the result obtained is only the mean effective diameter along the screw between that number of threads, which is an inaccurate condition if the gage is at all tapered.

The wire system of measuring the effective diameter is the most satisfactory, but only when properly carried out. The system used by the writer is to have two diameters of wires for each pitch of the thread; one to give the wire a bearing just on the theoretical effective diameter of a correct screw, and the other such that the wire rests in the screw just near its crest, but avoiding the rounding of the crest in the case of the Whitworth thread. The wires resting on the true pitch diameter of a correct screw are known as "best" diameter wires, and their sizes are as follows:

TABLE 2. BEST DIAMETER WIRES

Number of Threads per Inch	Best Diameter Wire	
	Whitworth Thread	U. S. Standard Thread
12	0.0470 inch	0.0481 inch
14	0.0403 inch	0.0412 inch
20	0.0282 inch	0.0289 inch
24	0.0235 inch	0.0241 inch
32	0.0176 inch	0.0180 inch
36	0.0156 inch	0.0160 inch
40	0.0141 inch	0.0144 inch

Machinery

These diameters are calculated from the simple formula:

Best diameter of wire $= D$;

Pitch of thread $= \dfrac{1}{\text{Number of threads per inch}} = P$;

Included angle of the thread $= A$;

then $D = \dfrac{P}{2} \times \sec \dfrac{A}{2}$.

For the different types of threads, we thus have:

Whitworth: $D = 0.5637P$;

U. S. Standard: $D = 0.5774P$;

British Association: $D = 0.5463P$.

The wire that bears near the crest of the thread is known as the "maximum" diameter wire, and for both the Whitworth and U. S. standard threads the size can be taken as 1½ times the best diameter wire for the same pitch.

Therefore the maximum diameter wires for the several pitches will be as follows:

TABLE 3. MAXIMUM DIAMETER WIRE

Number of Threads per Inch	Maximum Diameter Wire	
	Whitworth Thread	U. S. Standard Thread
12	0.0705 inch	0.0721 inch
14	0.0605 inch	0.0618 inch
20	0.0423 inch	0.0434 inch
24	0.0353 inch	0.0362 inch
32	0.0264 inch	0.0270 inch
36	0.0234 inch	0.0240 inch
40	0.0212 inch	0.0216 inch

Machinery

These maximum diameter D wires are calculated from:

Whitworth Thread: $D = 0.8456P$;

U. S. Standard Thread: $D = 0.8661P$;

British Association: $D = 0.8195P$.

It is not much use employing wires of a smaller size than the best diameter, as they would get too far down into the thread and give no free bearing on top for the micrometer. The thread micrometer, used in conjunction with the two sizes of wire recommended, will generally show anything wrong in the thread below the point where the wire bears, if the screw is correct in form. The wires must be accurately ground to size and be round; also, the exact size of the wire must be taken in a measuring machine to a hundred thou-

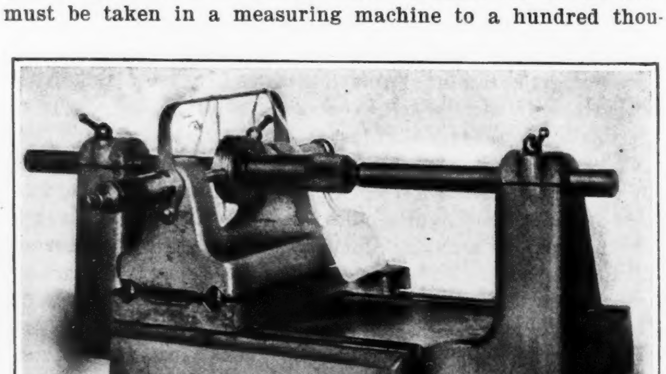


Fig. 3. Screw Measuring Machine used by the National Physical Laboratory of England

sandth of an inch. These conditions are most essential, because any difference in the diameter of the wire is multiplied by three (or more, see formula for K below), in the reading of the effective diameter. A convenient specification for wires is as follows:

1. Each wire must be round and to the diameter given; the combined error in roundness and diameter not to exceed 0.00005 inch.

2. Each wire must be measured on a measuring machine to 0.00001 inch and the mean diameter given on a label attached to the wire.

3. Each wire will be two inches long (this is an average size; for very large screws the length will be in proportion). Only the center half inch will be of the exact dimensions specified; the remaining portions of the wires can be blackened, and should be approximately 0.001 inch to 0.002 inch less in diameter than the central portion.

4. The wires are to be of hardened steel, and one end softened, and bored or turned over to make a loop to fasten the thread of the label to.

To use these wires a constant K must be calculated.

Let D = mean diameter of the two or three wires used;
A = included angle of the thread;
P = pitch of the thread.

Then: $$K = D\left(1 \cos\frac{A}{2}\right) - \left(\frac{P}{2}\cot\frac{A}{2}\right)$$

Thus, for the several types of thread, we have:

Whitworth:	$K = 3.1657D - 0.9605P;$
U. S. Standard:	$K = 3.0000D - 0.8660P;$
British Association:	$K = 3.4829D - 1.1363P.$

Given K, the micrometer reading over the wires minus K equals the pitch diameter of the screw. In use, the diameters of the wires should be checked from time to time for wear, and, if necessary, the constant K recalculated.

The common way to use the wires in workshops is to employ three in number, two in adjacent threads on one side of the screw and one in an intermediate position in the corresponding thread on the other side. The wires are usually held down into the screw by elastic bands. If the wires are sufficiently large in size not to bend under the pull of the bands, there is no objection, but often this is not so, and should the wires bend, a false reading is obtained. A better method is to use Johansson blocks in the holder provided with the set, and to make the distance between the jaws equal to the measurement over the wires corresponding to the correct effective diameter. The caliper so made is placed over the screw and the needles pushed into the thread; if the feel is not satisfactory, the distance between the blocks is varied by 0.0001 inch until it is. But the best system of measuring the effective diameter is to have a special machine for the purpose. In Fig. 3 is shown a machine designed by the National Physical Laboratory of England, consisting of a light carriage moving on balls in V-ways, across a platform, or base, underneath. On each side of the carriage are brackets, one of which carries a micrometer anvil which can be clamped in the bracket at any position along its length, and the other has a fixed micrometer head. By adjusting the position of the anvil, the gap of the micrometer can be arranged to suit the diameter of the gage being inspected, the zero of the reading being fixed by Johansson blocks. The carriage can be moved along the platform laterally to bring the micrometer opposite any thread of the screw; this motion is over small cylinders resting in V-ways in the platform and the under side of the carriage. Cylinders are used to permit an easy motion, but at the same time allow sufficient friction to keep the carriage in any given position. The screw gage is carried in adjustable centers in brackets on the ends of the platform. Across the carriage is a light steel support, with a narrow groove to allow the thread of the wires to pass, carrying the wires. An attachment for the Pratt & Whitney measuring machine has been made from designs by the writer, based on the principle of the screw measuring machine just described. With this attachment, master plug screw gages can be checked to about 0.0001 inch.

With these screw measuring instruments it is better to use one wire only at each side of the screw, of diameters as nearly equal as possible. The wires are suspended into the thread, opposite one another, and the micrometer head screwed in until it touches them. The feel is almost perfect because of the frictionless movement of the carriage. To check the core diameter of plug screw gages, small triangular pieces are employed, ground to an included angle of a few degrees less than that of the screw, the edge of the piece that bears on the thread being slightly rounded; these pieces are suspended in a similar way to the wires. The width across each triangular piece being known, the subtraction of the sum of the widths of the two pieces from the micrometer reading gives the core diameter of the screw. To check the core diameter, an ordinary micrometer, with the spindle ground to a convenient angle and the sharp point removed, may be used, or an ordinary micrometer may be employed in conjunction with triangular pieces, such as those described above for the machine. When the three ruling diameters of a screw have been checked, in planes at right angles to each other, at different points along the thread, the concentricity of these diameters should be measured over a few places. This is an important proceeding if separate laps are used for bringing the gage to size on the core, effective and full diameters, respectively, since, as this is thus done in three distinct operations, the diameters may not be concentric. Alterations in the structure of the steel after hardening would also cause the same defect. The same reasoning would apply to screws ground to size, when employing different wheels for correcting the three diameters. The eccentricity is readily found by using one wire or one triangular piece, in the diameter measuring machine previously referred to, and measuring the full diameter. Observations are made on the variation in reading the full diameter obtained during one revolution of the gage, keeping on the same thread. Eccentricity of core and effective diameters can be similarly found by using the triangular piece and wire, respectively, on opposite sides of the gage. Before leaving the subject of the measurement of the three diameters of plug screw gages, attention may be drawn to the difficulty of obtaining the core diameter correct within the low limit where the gage is ground to size. Also there are two other important objections to grinding to size. (1) The surface of the thread always has grinding marks, which bring about more friction when using the gage in the product, and so increased wear. (2) The rough surface of the thread may cause seizing of the gage in the product in the cases of a tight fit. Thus it is advisable to lap threads after grinding.

Checking Ring Screw Gages

The checking of ring screw gages is very little understood, as at present usually practiced. The common method is to employ a single screw plug of normal dimensions on the core, effective and full diameters; or else on the effective and full diameters only and with a low core diameter, so that a plain plug has to be used to check the latter element of the thread of the ring gage. If such checks go into the gage, the test is considered satisfactory. But, of course, it is not so, for the plug may give a good fit if it bears on one diameter only, and the other diameters of the ring gage could be large, beyond the tolerance. Logically, if in the case of a plug screw gage each diameter is checked separately, the same procedure should be observed in the case of a ring screw gage, but this is rarely done. Of course, it is practically impossible to so check a ring screw gage by direct measurements, but it can be carried out quite easily by indirect methods. For instance, if for a ring screw gage the following set of plug checks is provided, each diameter is duly taken care of. The checks are:

1. A "not go" full diameter check. This is a screw check of a full diameter equal to that of the ring screw gage, on the high limit. The angle between the slopes of the thread at the crest is made a couple of degrees less than the included angle of the normal thread. The rounding at the top of the thread is of sharp radius, and the core diameter that corresponding to a V-root. Such a check can only bear on the full diameter. Not more than a couple of threads are advisable, to minimize the effect of errors on the pitch entering into the result.

2. A "not go" effective diameter check. This has the effective diameter equal to the high limit of that element of the ring screw gage. The crest of the thread is made flat, and the root of the thread carried down to a vee. Two threads are enough. This check can only bear on the effective diameter of the screw ring gage.

3. A "go" effective diameter check. This is similar to No. 2, only the effective diameter is made to the low limit of the effective diameter of the screw ring gage.

4. A full form "go" check. This should have the dimensions of the low limits of the ring screw gage on the full, effective and core diameters, and contain the same number of threads. The rounding at the crest and root must be correct. Such a check tests the three diameters on the low limit, the roundness at the crest and root, and also proves that the pitch is correct if it screws right home into the gage.

5 and 6. "Go" and "not go" core diameter checks. These can be in the form of a double ended plain plug, with the two diameters the same as the high and low limits, respectively, of the core diameter of the ring screw gage.

The ruling diameters of each of these checks should not have a greater tolerance, in any case, than + 0.0001 inch for the "not go" checks and — 0.0001 inch for the "go" checks. The error in the pitch should not be beyond ± 0.0001 inch.

With a set of checks on this system the manufacturer knows at every stage of the finishing of the ring screw gage how the work is proceeding, and a great number of spoiled gages will be avoided by their use. For inspection purposes, a set of checks as above is also desirable, but not essential, since a ring screw gage can be satisfactorily inspected if only Nos. 1, 2, 3 and 4 are used.

The form of the thread of a ring screw gage is checked by No. 4, but as an additional measure it can be observed by taking a cast of the thread, employing such an apparatus as that shown in Fig. 2. The cast should be placed in a projection apparatus, so that an exact image, enlarged fifty times, can be thrown onto a screen and compared with a carefully drawn out enlargement of the thread made on cardboard and adjusted on the image.

In concluding this account of accurate methods of checking screw gages, a recapitulation of the essential equipment may be made. This should consist of:

1. A pitch measuring machine to read from thread to thread, to at least 0.0001 inch.

2. An appliance to take casts of ring screw gages, so arranged that the cast may be accurately set up in the pitch machine, or projection apparatus.

3. A screw measuring machine to check the governing diameters of a plug screw gage with accuracy to 0.0001 inch. An equipment of best diameter and maximum diameter wires, and triangular pieces for same.

4. Thread micrometers, checked for accuracy, to use in conjunction with the screw measuring machine.

5. Ordinary micrometers, to measure full diameters, with Johansson blocks to keep them accurate.

6. Complete sets of check plugs for the several diameters, pitch and form of thread of ring screw gages.

Finally, the equipment would be complete with a projection apparatus for observing the angle between the slopes of the thread, and the form of the thread.

* * *

STATE REVENUES

According to the United States Bureau of the Census, twenty-six states are not paying, from their revenues, their total expenses for governmental costs, interest on indebtedness and outlays for permanent improvements; and of this number eleven are not even meeting their current expenses and interest. In twenty-two states, however, the revenues exceed the total expenditures for current expenses, interest and outlays. The aggregate revenues of all the states during last year were $466,946,748; the aggregate expenditures for current governmental costs, including interest on indebtedness, $425,071,093; and the aggregate outlays for permanent improvements, $85,063,206. About 78 per cent of the total revenues is received from taxes.

SPECIFICATIONS AND INSPECTORS

A little knowledge is a dangerous thing, and nowhere, perhaps, as dangerous as in the mind of an inspector of war materials who tries to fulfill his duties conscientiously, but whose previous training for this work has not made it possible for him to master all the little details of mechanics and metallurgy. Recently, at a large factory building airplane motors for the government, the superintendent brought the inspector a record of the analysis made of some nickel steel specified in the contract. The specifications called for 3.5 nickel steel with certain physical properties, and the analysis read as follows: Nickel, 3.47 per cent; manganese, 0.63 per cent; phosphorus, 0.03 per cent; sulphur, 0.02 per cent; carbon, 0.33 per cent. When the inspector came to the carbon content, he promptly pushed the paper away from him, saying, "Rejected; this should be nickel steel and it contains carbon, and is a low carbon at that."

In another case, a conscientious inspector carefully added together the percentages of the chemical analysis for a nickel-chromium steel and found that the total of the chromium, nickel, manganese, carbon, phosphorus and sulphur added up to exactly 5.73 per cent. Turning to the superintendent, he said: "Your chemist must have made some mistake here; his analysis ought to add up to 100 per cent, and it only adds up to 5.73. Probably he has got the decimal point wrong somewhere!"

* * *

RESERVOIR CONTROL FOR OHIO RIVERS

Plans have been made for checking floods in the Miami Valley of Ohio which, it is confidently believed, will prevent a repetition of the Dayton disaster, the plans adopted being a combination of channel improvements and reservoirs. The system of reservoirs is capable not only of taking care of ordinary floods, but of emptying gradually into the river a flood lasting from eight to twenty days, if any such flood should occur. The reservoir control is to be accomplished by five retarding basins, one above Piqua, four above Dayton and one above Hamilton. These basins will be formed by dams built across the Miami, Mad and Stillwater Rivers, and some of the smaller streams. Each dam will have a permanent opening through its base through which the ordinary flow of the river will pass unimpeded. During large floods the water which cannot pass through the outlet conduits will be held back temporarily in the basins above the dams. The conduits are proportioned so that no more water can pass through them than can be carried safely in the channels through the cities below.

* * *

TECHNICAL MEN FOR U. S. SERVICE

The attention of technical graduates is called to the opportunities for war service in an announcement issued by Major J. E. Bloom, U. S. A., Newark, N. J. Men skilled in any line of science or mechanics, electrical or chemical work, ordnance, explosives, mining or shipbuilding, railroads, motors, metallurgy, building of airplanes, water supply or sanitation are urgently needed. The Army wants such men between the ages of eighteen and forty years to enlist for the period of the war. Men with a technical education but unable to volunteer are invited to cooperate by organizing guilds, societies and other bodies that can be made most helpful to government war work by expert direction.

* * *

EXPERT TOOLMAKERS WANTED

The National Bureau of Standards has not yet obtained all the men needed to fill expert toolmaker positions with salaries of $1500 per year. The duties in such positions are the making of apparatus for testing gages for military purposes. Seven and a half hours constitute a day's work, and a vacation of thirty days with pay is given except when conditions prevent. Men who are qualified to fill such positions are urged to communicate at once with the Bureau of Standards, Washington, D. C., stating their training and experience, age, place of birth and references.

WAR DEPARTMENT TOLERANCES FOR SCREW THREADS

The tolerances recorded in the accompanying table have been established by the Ordnance Department for use in the manufacture of artillery ammunition, trench warfare material, and gun parts, in cases where the U. S. standard form of thread is used. At the present time, nearly all ordnance designs of screw threads are based upon the "medium fit" given in the table, but it is proposed to use all three fits, in each case allowing the largest tolerance that can be permitted without affecting the proper function of the parts under consideration.

In the manufacture of artillery ammunition, where the parts are only expected to function temporarily, or perhaps only one time, it would manifestly be absurd to require such fits as are necessary on machinery subjected to vibration and wear. Another consideration of great importance is that the production is decreased when the closer fits are required, and evidently production is one of the main requirements at the present time. It is believed that manufacturers will find no difficulty in meeting the requirements of the medium fits, and judging by the experience of American manufacturers in fulfilling the early requirements of the British and Russian governments, there should be little difficulty in meeting even the close fits.

The last column in the table, which gives the minimum strength corresponding to the various fits on the assumption

ORDNANCE DEPARTMENT TABLE OF TOLERANCES FOR SCREW THREADS (U. S. STANDARD FORM)

CLOSE FIT

Number of Threads per Inch	Tolerances on Screws			Neutral Space between Maximum Screw and Minimum Nut	Tolerances on Nuts			Minimum Per Cent Strength (Approximately)
	D Full Diameter	E Effective Diameter	K Core Diameter		D_1 Full Diameter	E_1 Effective Diameter	K_1 Core Diameter	
4–6	+ 0.000 — 0.008	+ 0.000 — 0.008	+ 0.000 — 0.025	0.008	— 0.000 + 0.025	— 0.000 + 0.008	— 0.000 + 0.008	87
7–10	+ 0.000 — 0.006	+ 0.000 — 0.006	+ 0.000 — 0.016	0.006	— 0.000 + 0.016	— 0.000 + 0.006	— 0.000 + 0.006	84
11–18	+ 0.000 — 0.005	+ 0.000 — 0.005	+ 0.000 — 0.010	0.005	— 0.000 + 0.010	— 0.000 + 0.005	— 0.000 + 0.005	76
20–28	+ 0.000 — 0.004	+ 0.000 — 0.004	+ 0.000 — 0.008	0.004	— 0.000 + 0.008	— 0.000 + 0.004	— 0.000 + 0.004	70
30–40	+ 0.000 — 0.003	+ 0.000 — 0.003	+ 0.000 — 0.006	0.003	— 0.000 +0 .006	— 0.000 + 0.003	— 0.000 + 0.003	68
44–56	+ 0.000 — 0.002	+ 0.000 — 0.002	+ 0.000 — 0.004	0.002	— 0.000 + 0.004	— 0.000 + 0.002	— 0.000 + 0.002	70
64–80	+ 0.000 — 0.0015	+ 0.000 — 0.0015	+ 0.000 — 0.003	0.001	— 0.000 + 0.003	— 0.000 + 0.0015	— 0.000 + 0.0015	70

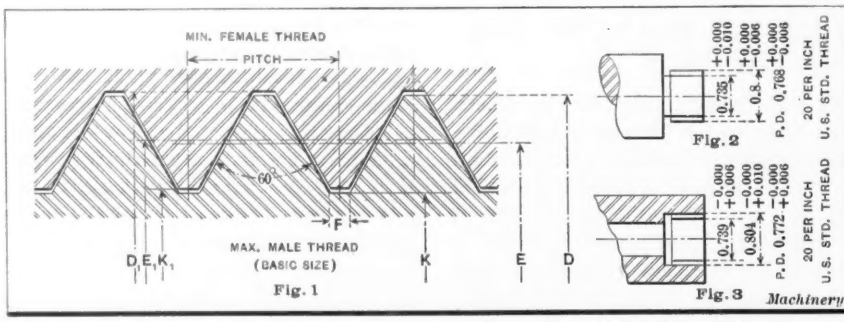
MEDIUM FIT

Number of Threads per Inch	Tolerances on Screws			Neutral Space between Maximum Screw and Minimum Nut	Tolerances on Nuts			Minimum Per Cent Strength (Approximately)
	D Full Diameter	E Effective Diameter	K Core Diameter		D_1 Full Diameter	E_1 Effective Diameter	K_1 Core Diameter	
4–6	+ 0.000 — 0.016	+ 0.000 — 0.016	+ 0.000 — 0.035	0.008	— 0.000 + 0.035	— 0.000 + 0.016	— 0.000 + 0.016	78
7–10	+ 0.000 — 0.012	+ 0.000 — 0.012	+ 0.000 — 0.022	0.006	— 0.000 + 0.022	— 0.000 + 0.012	— 0.000 + 0.012	72
11–18	+ 0.000 — 0.008	+ 0.000 — 0.008	+ 0.000 — 0.014	0.005	— 0.000 + 0.014	— 0.000 + 0.008	— 0.000 + 0.008	65
20–28	+ 0.000 — 0.006	+ 0.000 — 0.006	+ 0.000 — 0.010	0.004	— 0.000 + 0.010	— 0.000 + 0.006	— 0.000 + 0.006	60
30–40	+ 0.000 — 0.004	+ 0.000 — 0.004	+ 0.000 — 0.007	0.003	— 0.000 + 0.007	— 0.000 + 0.004	— 0.000 + 0.004	60
44–56	+ 0.000 — 0.003	+ 0.000 — 0.003	+ 0.000 — 0.005	0.002	— 0.000 + 0.005	— 0.000 + 0.003	— 0.000 + 0.003	59
64–80	+ 0.000 — 0.002	+ 0.000 — 0.002	+ 0.000 — 0.003	0.001	— 0.000 + 0.003	— 0.000 + 0.002	— 0.000 + 0.002	63

LOOSE FIT

Number of Threads per Inch	Tolerances on Screws			Neutral Space between Maximum Screw and Minimum Nut	Tolerances on Nuts			Minimum Per Cent Strength (Approximately)
	D Full Diameter	E Effective Diameter	K Core Diameter		D_1 Full Diameter	E_1 Effective Diameter	K_1 Core Diameter	
4–6	+ 0.000 — 0.030	+ 0.000 — 0.030	+ 0.000 — 0.045	0.008	— 0.000 + 0.045	— 0.000 + 0.030	— 0.000 + 0.030	61
7–10	+ 0.000 — 0.020	+ 0.000 — 0.020	+ 0.000 — 0.030	0.006	— 0.000 + 0.030	— 0.000 + 0.020	— 0.000 + 0.020	56
11–18	+ 0.000 — 0.012	+ 0.000 — 0.012	+ 0.000 — 0.018	0.005	— 0.000 + 0.018	— 0.000 + 0.012	— 0.000 + 0.012	51
20–28	+ 0.000 — 0.008	+ 0.000 — 0.008	+ 0.000 — 0.012	0.004	— 0.000 + 0.012	— 0.000 + 0.008	— 0.000 + 0.008	48
30–40	+ 0.000 — 0.006	+ 0.000 — 0.006	+ 0.000 — 0.008	0.003	— 0.000 + 0.008	— 0.000 + 0.006	— 0.000 + 0.006	45
44–56	+ 0.000 — 0.004	+ 0.000 — 0.004	+ 0.000 — 0.006	0.002	— 0.000 + 0.006	— 0.000 + 0.004	— 0.000 + 0.004	48
64–80	+ 0.000 — 0.003	+ 0.000 — 0.003	+ 0.000 — 0.004	0.001	— 0.000 + 0.004	— 0.000 + 0.003	— 0.000 + 0.003	47

Machinery



Figs. 1 to 3. Illustrations showing the War Department's Method of giving Tolerances on Screw Threads

that the male and female threads have the same lead, will prove of considerable interest. The figures give the strength in per cent of the strength of the unthreaded bolt.

In connection with drawings of screw threads, the Ordnance Department specifies that all diameters of the maximum male thread, or basic size, are to be expressed in the closest thousandth of an inch. In the table, the expressions "full diameter," "effective diameter," and "core diameter" are used. The full diameter is the outside diameter; the effective diameter is what is also often known as "pitch diameter" or "angle diameter"; and the core diameter, what is frequently known as "root diameter." The tolerances specified in the various classes of fits for the core diameter of a screw and the full diameter of a nut differ from those specified for the other diameters. This condition results in the possible production of a thread of which the flat at the root is less than that of an accurate U. S. form of thread. This is permitted in order to allow additional wear of the cutting tools and thus facilitate the manufacture. The tolerances for the core diameters of screws and the full diameters of nuts are so proportioned that taps and threading tools may be made with a flat which is 75 per cent of the standard flat. In order to prevent errors in the construction of gages and threading tools, however, a note should appear conspicuously on all part drawings, as follows: "Threads do not conform at root to U. S. form, owing to the additional tolerances allowed."

In the accompanying illustration, Fig. 1 illustrates the condition of what might be called the "neutral" space, when the female part, or nut, is at its minimum and the male part, or screw, is at its maximum. The maximum screw is the basic size from which all dimensions are computed. All tolerances applied to the diameters on the screw are "minus" (—); all tolerances applied to the diameters on the nut are "plus" (+). Fig. 2 illustrates the dimensions and application of the tolerances of a screw as they would be given on a drawing, and shows how a screw thread of medium fit would be dimensioned. Fig. 3 shows the dimensions and tolerances of a nut corresponding to the screw shown in Fig. 2.

* * *

CONTINUOUS MILLING

In any scheme of so-called "continuous milling" the object is to keep the cutters at work the maximum time possible. Continuous milling machines are of the rotary work-table and planer-table types. The rotary table machine is set with its table axis either vertical or horizontal. The vertical axis type has the advantage of easy loading and inspection of the cutter at work, while the horizontal axis table can be made to work between opposed cutters, which mill the pieces on both ends simultaneously and to length. This machine requires a polygonal work-table with work-holding fixtures on the respective faces. More time is lost while the cutter is feeding from one piece to the next in the horizontal axis machine than on the vertical because of the fixed diameter of the loading circle, but this lost time may be considerably reduced by automatically speeding up the feed motion between cuts.

The planer-table type machine may be used for continuous milling in several ways. The work pieces may be strung on the table and milled with the table feeding "against the cutter" until the limit of traverse is reached, and then the feed is reversed to travel "with the cutter." The work pieces are removed as soon as finished and replaced by others. The objection to this method is the difference in cutter action on the forward and return feed. Another method successfully employed in motor car work is to remove parts as soon as they are milled and return the table by a quick traversing motion. The work pieces in the first rank are quickly clamped in position and the feed thrown in. The filling up of the table is done while the pieces first placed are being milled. This plan is most successful on large machines on which two men can be kept busy. On light milling suited to Lincoln type machines the "drop table" may be employed to secure rapid production. The table is reloaded as the work is milled, and at the end of the traverse it drops a fraction of an inch to clear the cutters and reverses. On completing the reverse motion, the table rises to the cutting level and the operation is repeated. In this way the work always approaches the cutter from the same side.

A new way of continuous milling on planer-type machines has come into limited use during the past few years, which is known as the removable platen method. The work is loaded onto a short platen while at rest on a bench alongside of the machine, and the platen is then hoisted and lowered onto the ways. A rack on the under side engages the longitudinal feed-screw and feeding toward the cutter begins. Meanwhile a platen ahead carrying similar parts has passed beyond the cutters and is ready to be unloaded. This is hoisted and trolleyed to the head end of the machine and lowered onto the bench, where the work is removed and more pieces put on. The operation is thus kept up continuously. The minimum number of platens required is two, but three, four or five are often used.

* * *

ANNUAL CONVENTION OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

As the keynote of the annual convention of the American Society of Mechanical Engineers, which was held in New York City, December 4 to 7, was the service rendered by the mechanical engineer in time of war, it is evident that all the important papers and sessions had some bearing upon war work. The report by the gage committee and the resolution passed in connection with the presentation of this report is mentioned elsewhere in this number; the machine shop session also being concentrated upon gaging and inspection, gave this subject due prominence during the convention. It may be expected that on the basis of what was said and done further progress will be made, and more detailed attention given to many of the important problems in connection with the manufacture and inspection of war materials.

Charles T. Main, who was elected president of the society, has for many years been prominent as a consulting engineer in Boston, having designed and supervised the construction of many steam and water power plants, some of his largest undertakings being the Wood Worsted and the Ayer Mills in Lawrence, Mass., and four hydraulic developments for the Montana Power Co., aggregating about 280,000 horsepower. Mr. Main has been a member of the American Society of Mechanical Engineers since 1885 and has served on its board of managers for the past three years. He is also a member of the American Society of Civil Engineers. Since 1892 he has practiced as a consulting engineer, and until 1907 was associated with F. W. Dean in the firm of Dean & Main.

The conferring of honorary membership upon Major-General George W. Goethals in recognition of his achievements in engineering and the presence of ex-President Taft, who addressed the society at the opening session, were events that marked the convention and aided in making it an important event in the history of the society. The spring meeting this year will be held in Worcester, Mass., the exact date not having been yet definitely settled upon.

* * *

Of the 131 electric steel melting furnaces in Great Britain, 70 are in Sheffield, which is probably the largest number of such furnaces in any one center in the world.

NEW MACHINERY AND TOOLS

THE COMPLETE MONTHLY RECORD OF NEW AMERICAN METAL-WORKING MACHINERY

IN THIS NUMBER

WEBSTER & PERKS NO. 1 UNIVERSAL CYLINDRICAL GRINDER

In a No. 1 universal cylindrical grinding machine which has recently been placed upon the market by the Webster & Perks Tool Co., Springfield, Ohio, the design has been worked out to secure the combined features of rigidity in the machine and accuracy of the work produced on it. Of course, these two conditions are closely related; in fact, they represent a typical example of cause and effect. Exceptionally heavy sliding and swivel tables are provided on the machine, and the

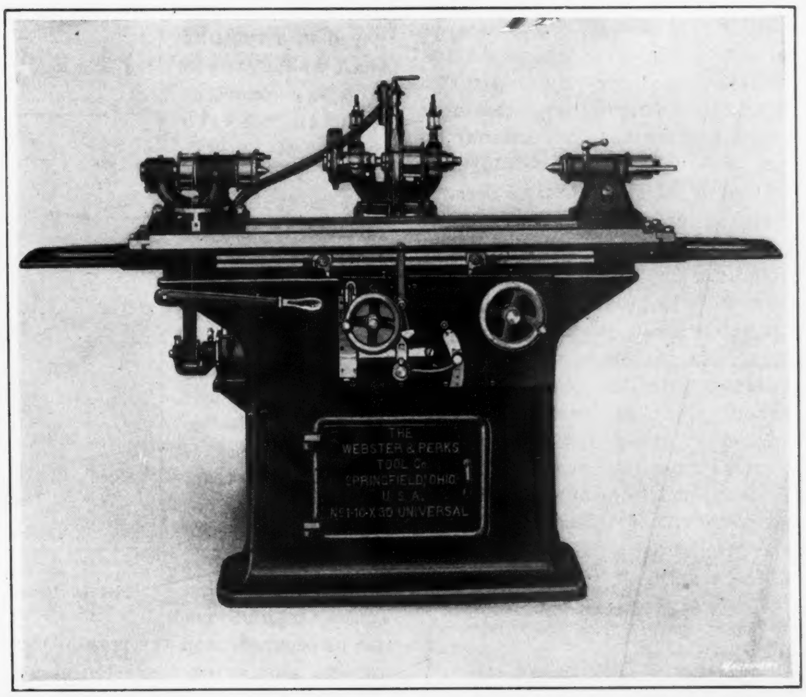


Fig. 1. No. 1 Universal Cylindrical Grinder built by Webster & Perks Tool Co.

wheel-stand is furnished with large bearing surfaces. The table drive and cross-feed mechanism are assembled in a unit, making it an easy matter to remove them from the machine. The wheel-stand and head-stock bearings are liberally proportioned, and the dead center pulley bearing is equipped with a double-row ball bearing. Both the head-stock and tailstock are aligned against the front edge of the swivel table by T-head bolts engaged in a 45-degree angle T-slot in

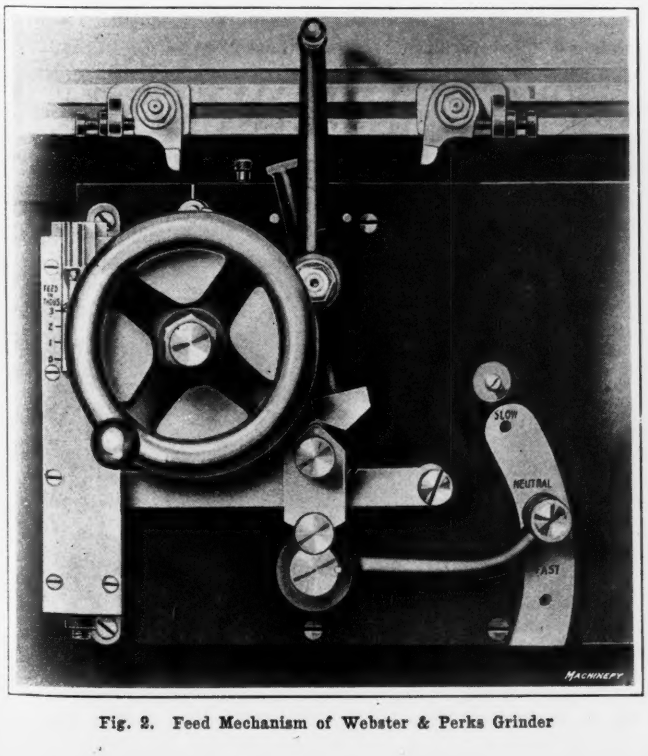


Fig. 2. Feed Mechanism of Webster & Perks Grinder

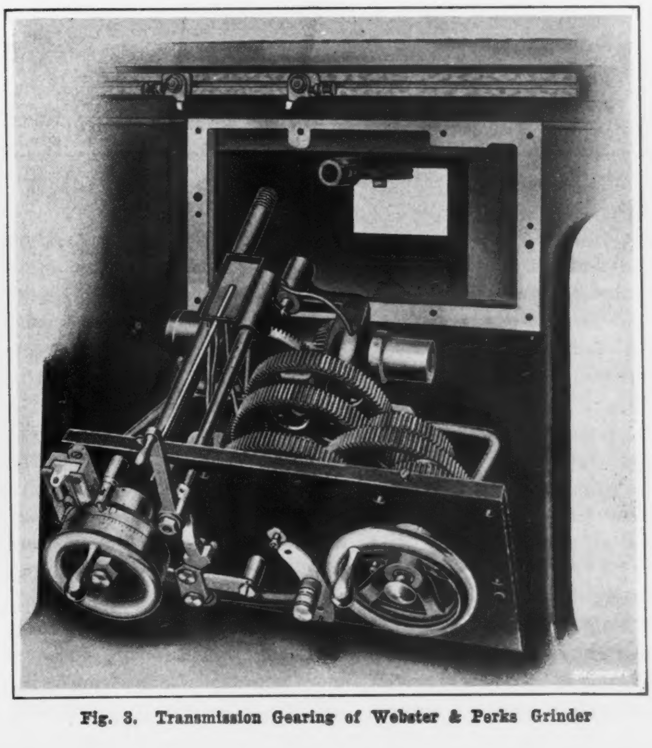


Fig. 3. Transmission Gearing of Webster & Perks Grinder

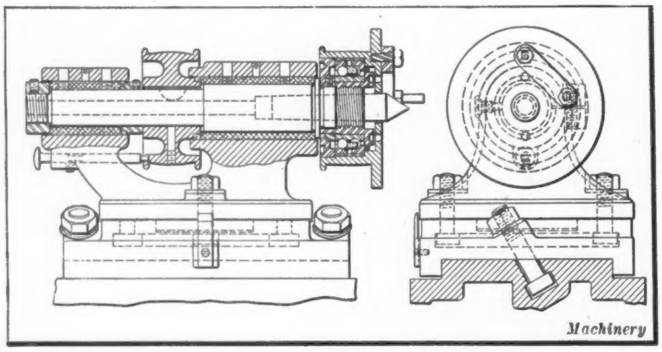


Fig. 4. Arrangement of T-bolts for accurately aligning Ball-bearing Tailstock

the swivel table, which insures absolutely accurate alignment. This arrangement will be best understood by referring to Fig. 4.

Automatic cross-feed permits of feeding at either or both ends of the table travel by means of a movable cam roller. The micrometer feed is controlled by a knurled nut which gives a quick reading from 0.00025 to 0.004 inch. The arrangement of this feed mechanism is shown in Fig. 2 and it is said to be very satisfactory in operation. A lever at the front of the machine provides for obtaining either fast or slow table travel, and with a four-step cone pulley on the countershaft eight changes of table speed are obtainable. Fig. 5 shows the arrangement of an internal grinding attachment provided for use on this grinding machine; the internal attachment and countershaft are both equipped with adjustable ball bearings which are required in this connection because the internal attachment is designed for operation at speeds of 15,880 and 19,600 R.P.M.

In developing this new grinding machine, the Webster & Perks Tool Co. has made every effort to provide an equipment which will grind work within the most exacting limits of accuracy that can be expected from machines of this type; and an effort has also been made to simplify the design and construction in order to reduce as far as possible the possibility of the machine getting out of order, and also to eliminate all unnecessary complications from the operation.

The principal dimensions of the machine are as follows: range, for handling work up to 10 by 30 inches; maximum diameter of work that can be ground with full sized wheel, 10⅜ inches; maximum grinding length, 32 inches; range of

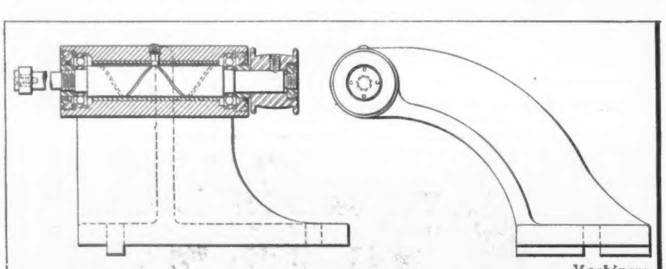


Fig. 5. Internal Grinding Attachment for Use on Machine shown in Fig. 1

graduations on swivel table, 8 degrees; range of graduations on headstock, 90 degrees; length of headstock bearings, 3 and 4 inches, respectively; range of graduations on wheel-slide base, 90 degrees each side of center; width of wheel driving belt, 2 inches; dimensions of grinding wheel, 10 inches in diameter by ¾ inch face width; diameter of hole in grinding wheel, 3 inches; dimensions of end grinding wheel, 6 inches in diameter by ½ inch face width; diameter of hole in end grinding wheel, 2 inches; minimum reduction by automatic cross-feed, 0.00025 inch; maximum reduction by automatic cross-feed, 0.004 inch; minimum reduction indicated by cross-feed handwheel dial, 0.00025 inch; number of available work speeds, 4; number of available table speeds, 8; range of table speeds, 7 to 70 feet per minute; number of wheel speeds, 2; available wheel speeds, 2250 and 2800 revolutions per minute; type of bearings used in countershaft, Hyatt roller; speed of countershaft, 300 revolutions per minute; width of countershaft driving belt, 4 inches; floor space occupied by machine, 43 by 112 inches; and complete weight of machine, approximately, 3600 pounds.

NOBLE & WESTBROOK MARKING MACHINE

In Fig. 1 there is shown a special machine for impressing graduations and figures on circles and half circles in a single operation. This machine is a recent product of the Noble & Westbrook Mfg. Co., Hartford, Conn., and represents an addition to the line of marking machines of this company's manufacture. It is of simple construction, accurate, and easy to operate; and its use effects quite a saving for the manufacturer when a large quantity of pieces has to be graduated. The graduating die is carried in a holder keyed to a rotating shaft which runs in bronze bearings provided with means of adjustment. The work is held in the proper relation to the die with accurately cut gears, and the depth of impression is provided by foot pressure applied through a lever and cam, which is adjustable so that it is possible to regulate the depth of impressions to 0.010 inch. This means that even and accurate impressions can be secured; and the possibility of completing the graduating and numbering operation at a single turn of the machine assures a highly satisfactory rate of production. Machines of this type are suitable not only for graduating round circles, but also half circles of the kind used on compound rests for lathes and for numerous other classes of work. An idea of the range of work handled will be obtained from Fig. 2

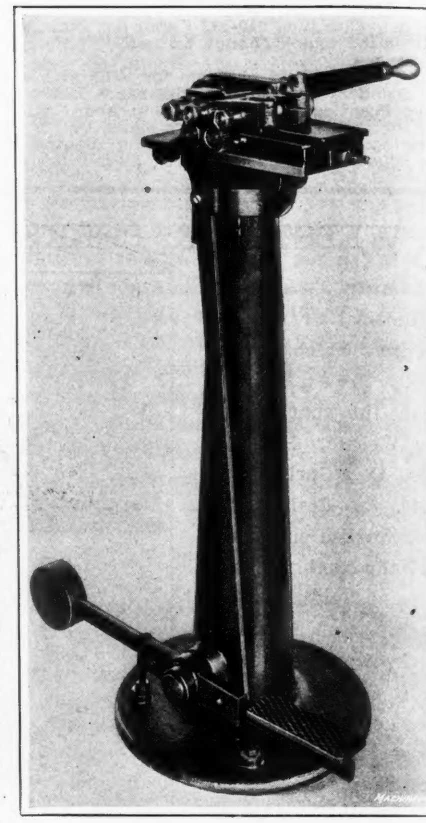


Fig. 1. Graduating and Marking Machine built by Noble & Westbrook Mfg. Co.

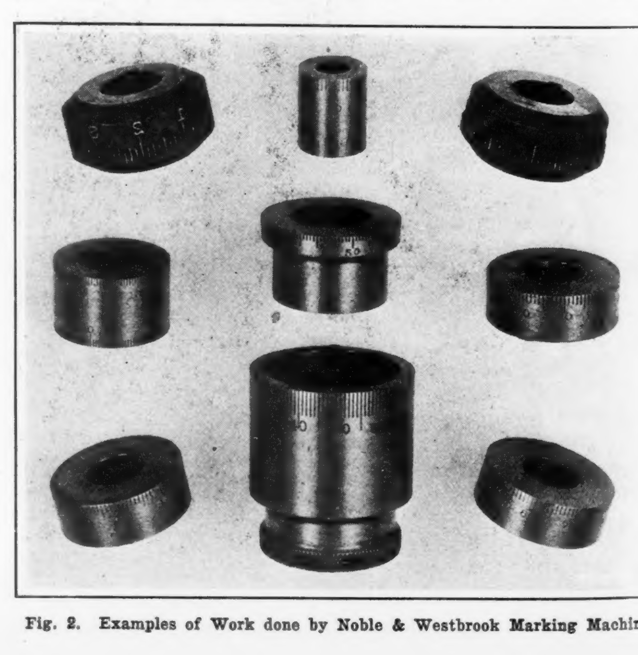
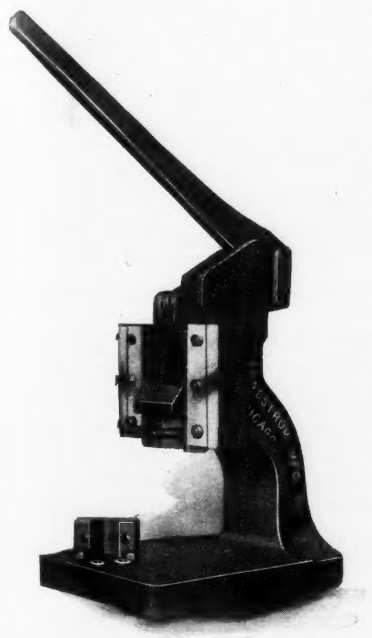


Fig. 2. Examples of Work done by Noble & Westbrook Marking Machine

SUNDSTROM DIE TESTING PRESS

The "Rex" die testing press was originally designed and built by the Sundstrom Mfg. Co., 3201 Shields Ave., Chicago, Ill., for use in its own shop in spotting dies, shearing and scraping in punches, etc., but has proved so satisfactory a tool that a decision was recently reached to build the press for the market. It is stated that the ideal way to use this press is to place one between each two mechanics in the tool-room, who are engaged on die work, so that the press may be used for die testing without requiring men to leave their bench. With such an equipment no time is lost by having men carry their work to a large press, and there is not the tendency for men to stand around and "visit" while some other mechanic is working the machine which they desire to use, but serious as this loss of time is sure to be, it is liable to be cumulative in its effect, because a mechanic will often have to go back and forth several times between his bench and the press before he has secured the desired result. Also, the heavy press may destroy a die that is being tested under it. With these convenient bench presses, the men lose no time and the work of testing a die may be performed with greater rapidity than on a large machine.



"Rex" Die Testing Press built by Sundstrom Mfg. Co.

The principal dimensions of the "Rex" die testing press are: die space with ram down, 6½ inches; stroke of press, 1¼ inch; depth of throat, 7 inches; capacity of square shank holder, for shanks up to 2 inches in diameter; ratio of leverage, 20 to 1; and weight of press, about 260 pounds.

PROGRESSIVE DRILL CHUCK

The Progressive Machine & Metal Products Co., Inc., 210-212 Canal St., New York City, is now manufacturing the quick-change drill chuck shown in Fig. 1. Probably a better conception of the way in which this chuck operates will be gathered by referring to the cross-sectional view, Fig. 2. This chuck is intended for driving taper shank drills, and it will be seen that the tang at the end of the drill shank extends up into a slot *A* which is cut in the chuck body that is integral with the shank of the chuck. To provide for centering the drill in the chuck, a block *B* is provided which has a taper hole corresponding to the taper of the drill shank. When the drill is not in contact with the work, two springs *C* force block *B* down onto the drill shank, so that frictional resistance may be depended upon to hold the drill in place in the chuck. Shell *D* and inner case *E* are held together by screws, and it will be seen that there is a 1/8-inch space between the top of shell *E* and the annular flange on block *B*. When it is desired to release a drill from the chuck, the operator grasps shell *D* and pushes it up until the top of case *E* strikes the flange on block *B*. In this position the drill can be removed from the chuck and another drill substituted. These drill chucks are made in two sizes to carry drills with No. 1 and No. 2 Morse taper shanks.

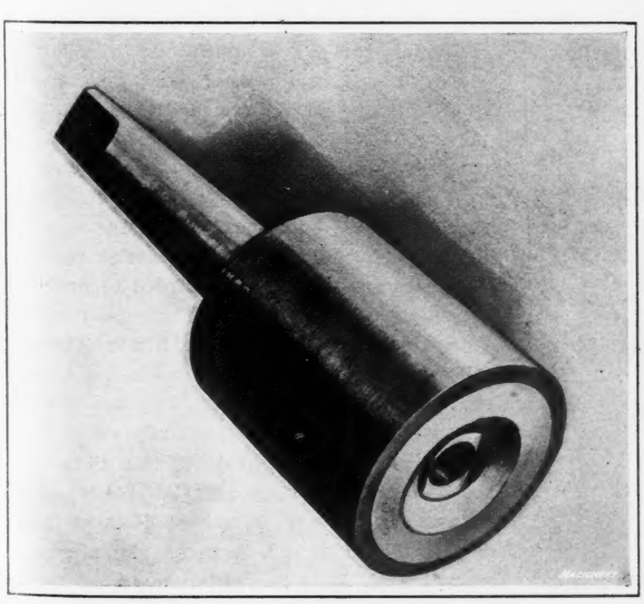


Fig. 1. Drill Chuck made by Progressive Machine & Metal Products Co.

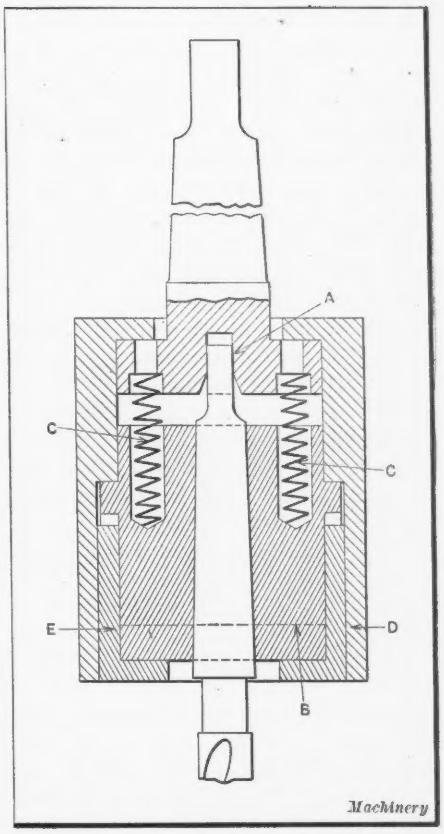
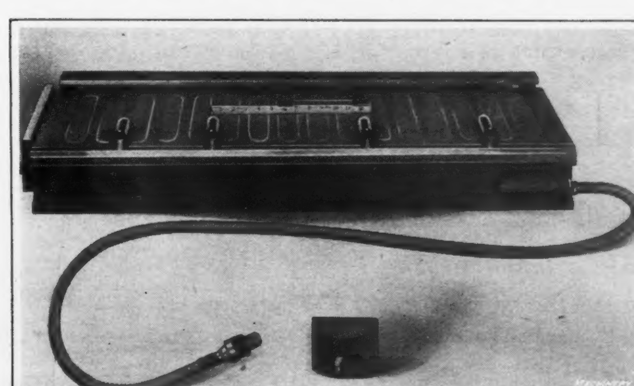


Fig. 2. Cross-sectional View of Progressive Chuck, showing Method of Operation

HEALD MAGNETIC CHUCK

In the accompanying illustration there is shown a Style 1436 rectangular magnetic chuck which is manufactured by the Heald Machine Co., 20 New Bond St., Worcester, Mass. This chuck has a large working surface, and it is claimed that the holding power is approximately 200 pounds per square inch with a current consumption of 300 watts, this high efficiency being obtained through a special arrangement of the magnetic coils. In the body there are two cores and two coils for each pole piece in the working surface of the chuck, and the coils are made up of enameled insulated wire of large gage. There is plenty of space in the interior of the chuck between the coils, which reduces to a minimum the possibility of developing short circuits. Another desirable feature, which is a result of the liberal air space in the interior of the chuck,



Rectangular Magnetic Chuck made by Heald Machine Co.

is that no ventilation is required and the chuck can be used wet or dry without change.

At the right-hand end of the chuck there is a "volt box" which is integral with the body and designed so that the user may change the voltage from 110 to 220 volts, or *vice versa*, without returning the chuck to the factory. Access is made to the box by removing the pipe bushing, and when this is again screwed into place after the change has been made, an absolutely waterproof connection is provided. The lead wires are protected by a heavy armored conduit, and the end of this cable terminates in a standard attaching plug. A special demagnetizing switch is furnished with the chuck, and the unit coil system of construction not only provides liberal holding power, but also assures a practically uniform holding power over the entire chuck surface. Another feature of this chuck is that the faceplate or top plate is removable and interchangeable, making it possible to replace an old plate with a new one without requiring any change in the original body and complete set of coils.

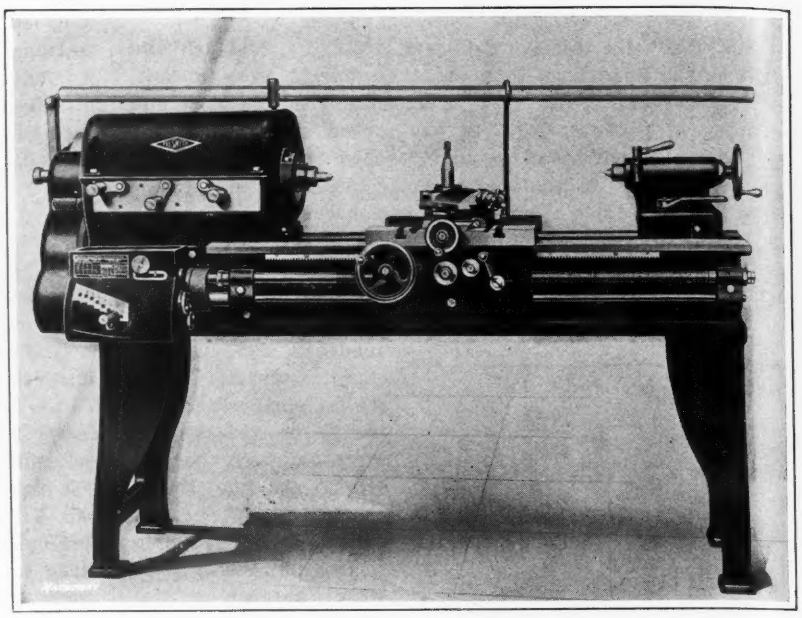


Fig. 2. "Filsmith" 14-inch Quick-change Engine Lathe with All-geared Head

The top plate is made of liberal thickness, so that a great amount of wear and resurfacing can be obtained before it is worn out. This plate is attached to the body of the chuck by hex-headed cap-screws which are closely spaced, and draw the plate down firmly onto the chuck body. The screws enter the top plate from the under side, extending up through the body, so that there are no screw holes in the working surface of the chuck where water and grit can find their way into the interior. The front edge of the top plate is provided with a T-slot to receive straps, fingers, etc., which may be required to hold the work; and adjustable side-stops and end-stops are also provided. The ends of the chuck are machined, so that it is possible to shove one chuck tight against another, in cases where two or more chucks may be used to advantage for holding long work. As previously mentioned, the chuck is adaptable for either 110 or 220 volts direct current, and if the right current or voltage is not readily obtainable, a suitable direct-current generator can be furnished to belt direct to a countershaft.

"FILSMITH" QUICK-CHANGE LATHES

In Fig. 1 is shown a high-power 14-inch quick-change engine lathe equipped with a three-step cone pulley and double backgears, which is a recent product of the Philip Smith Mfg. Co., Sidney, Ohio. Lathes of this type are also built with a geared head, as shown in Fig. 2, which provides twelve changes of speed; this head is heavily constructed and made oil-tight, so that flooded lubrication may be employed. The spindle bearings are bushed with phosphor-bronze and all gears are pack-hardened, with the holes ground true to the pitch line of the gears. The entire transmission runs on ball bearings, and all changes of speed are made from the front of the head. The range of available speeds is from 18 to 479 R.P.M. This head is of the friction pulley type and can be run direct from the lineshaft or through a countershaft. The spindle is made of 50-point carbon crucible steel and accurately ground to size.

This machine is built with a bed which has heavy walls and box girders to provide the necessary strength. The tailstock is rigidly clamped to the bed and so shaped that the compound rest can be set at right angles when the lathe is engaged in turning pieces of small diameter. A bearing 18 inches in length is provided for the carriage, and the bridge is 7¼ inches wide. The compound rest is furnished with taper gibs and is graduated in the usual way. When so desired, a plain rest may be substituted for the compound rest. A feature of the apron is that it is cast with the bearings an integral part of the apron, which affords a stiff construction. All small apron gears are made of steel and the studs are hardened and ground to size. A safety device prevents throwing in the half-nuts when either feed is connected. The power cross-feed and compound rest screws are provided with the usual graduated dials and the lead-screw is cut from a master, which is frequently tested to assure the maintenance of its accuracy. The quick-change gearbox is furnished with either the cone-driven machine or the geared-head machine and provides for cutting threads from 4 to 46 per inch. Special gears can be furnished to provide for the performance of special operations, which do not come within the range of the machine. The lead-screw is disengaged by means of a slip gear, so that it only runs while the lathe is engaged in the performance of thread-cutting operations. All gears are thoroughly guarded to provide for the safety of the operator. Equipment furnished with this machine includes a compound rest, follow-rest, steadyrest, double friction countershaft, large and small faceplates and the necessary wrenches for making all adjustments.

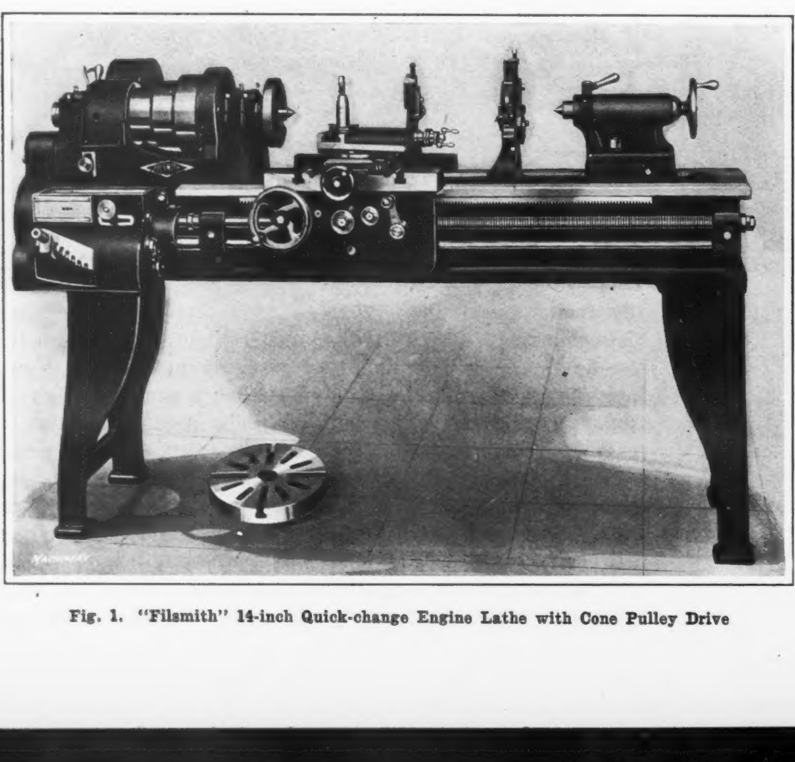


Fig. 1. "Filsmith" 14-inch Quick-change Engine Lathe with Cone Pulley Drive

The principal dimensions of this 14-inch lathe are as follows: swing over bed, 14 1/8 inches; swing over carriage, 9 inches; distance between centers for 6-foot bed, 35 inches; maximum tailstock travel, 5 1/4 inches; diameter of tailstock spindle, 1 3/4 inch; taper of centers, No. 3 Morse; dimensions of the front spindle bearing, 2 3/8

by 4 inches; dimensions of the rear spindle bearing, 1 13/16 by 3 inches; diameter of hole through spindle, 1 5/16 inch; diameter of spindle nose, 2 1/16 inches; range for thread cutting, 4 to 46 threads per inch; range of feeds, three times threads; cone pulley diameters, 5 1/2, 6 1/4 and 8 inches; width of driving belt, 2 1/2 inches; size of countershaft pulleys, 10 by 3 1/2 inches; ratio of back-gears, 3 to 1 and 8 to 1; number of spindle speeds, 18; countershaft speeds, 300 and 400 R.P.M.; range of spindle speeds, 27 to 600 R.P.M.; toolpost capacity, for tools up to 1 1/4 by 5/8 inch; and weight of machine with 6-foot bed, 1350 pounds. Machines of this type are also built in a 16-inch size, and similar machines of the gap bed type are built in 14- and 16-inch swings.

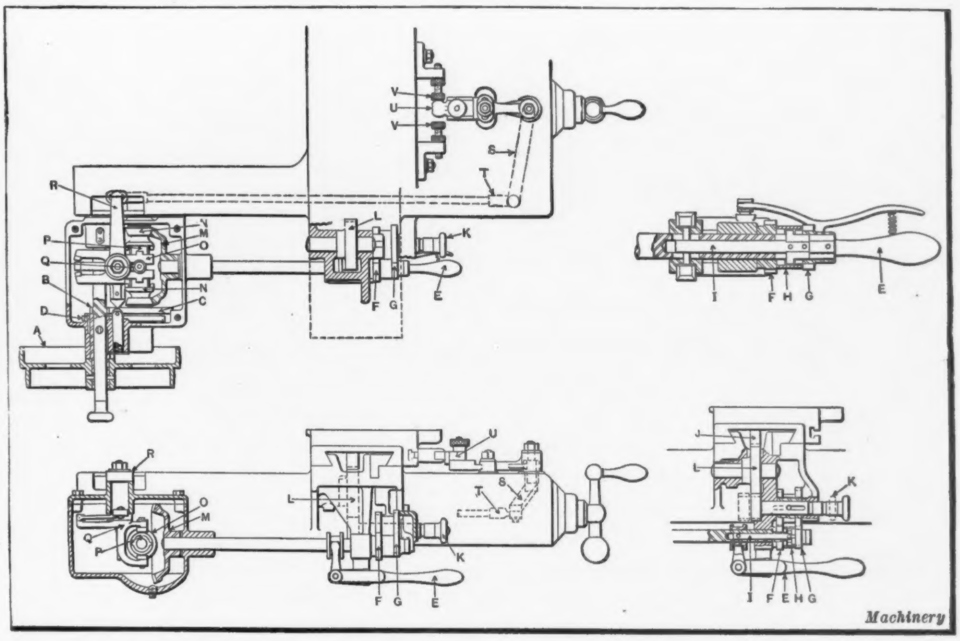


Fig. 2. Details of Automatic Feed Mechanism for Wilmarth & Morman Tool Grinder

AUTOMATIC FEED MECHANISM FOR WILMARTH & MORMAN UNIVERSAL CUTTER AND TOOL GRINDER

The Wilmarth & Morman Co., 1180 Monroe Ave., N. W., Grand Rapids, Mich., is now equipping its No. 1 universal cutter and tool grinder with an automatic feed mechanism. As will be noted from the illustration of the complete machine shown in Fig. 1, the means of obtaining the drive on this reversing mechanism is provided by a gear-box with all the mechanism necessary for obtaining the eight table speeds contained in one unit. This is arranged so it can be attached to the hand feed machines of this type already in service, with very little work. The gear-box is attached to the saddle on a pad at the rear, and is driven by a two-step cone pulley *A*, Fig. 2, from the main countershaft, this cone pulley providing two changes of speed. The sliding pinion shaft *B* engaging with two-step gear *C* provides one speed; and sliding the pinion shaft out of engagement and engaging the key with gear *D*, changes the speed, making a second speed from the same pulley.

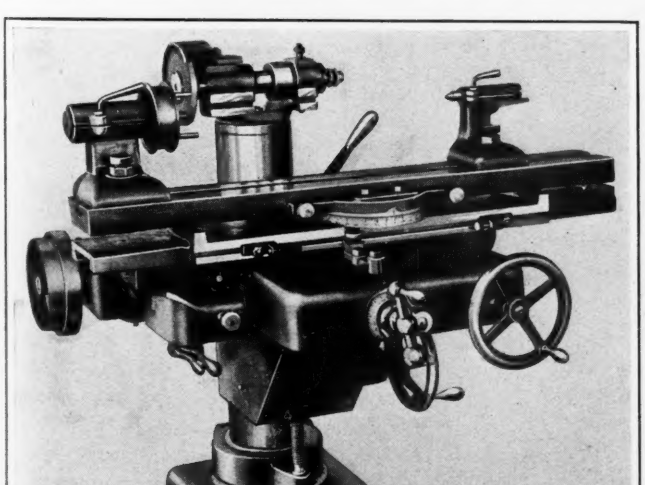
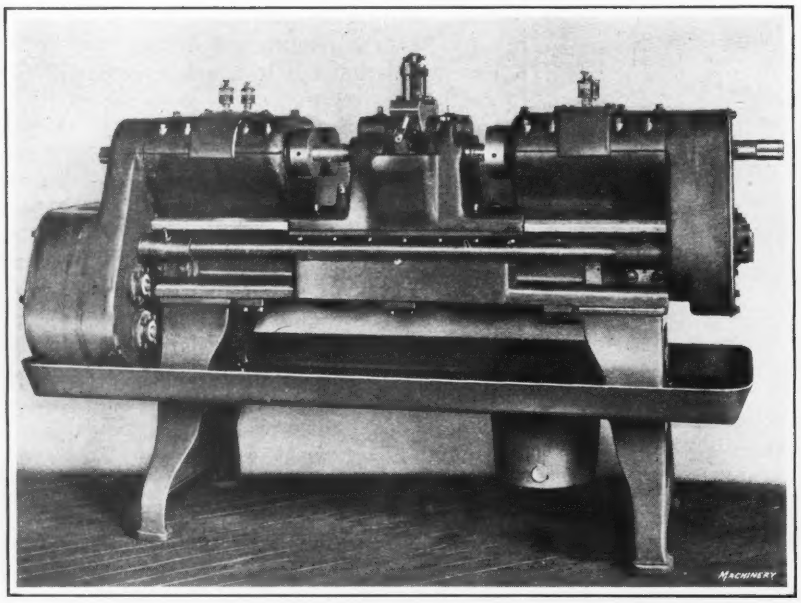


Fig. 1. Wilmarth & Morman No. 1 Universal Cutter and Tool Grinder equipped with Automatic Feed Mechanism

Two other changes of speed are obtained in the bracket or bank of gears with the starting lever *E*, which is engaged with the sliding shaft *I* by a key working through a slot, being thrown into engagement with the two clutch gears *F* and *G*. This starting lever *E* is held in position by a plunger actuated by a lever and spring to lock it in position when a change is made by this lever. The two clutch pinions *F* and *G* are spaced by a collar *H*, which allows the same sliding shaft *I* to be held in a neutral position, disengaging this shaft and establishing a neutral position, and in that way disengaging the mechanism from operating the table. Engaging the key on shaft *I* with gear *F* by moving lever *E*, gives a third speed of the table; then by disengaging lever *E* from pinion *F* and engaging it with pinion *G*, the fourth speed of the table is obtained. To obtain four other speeds in the mechanism, simply shift the belt onto the other step of pulley *A*. Lever *E* is also used for stopping the table.

It will be noted that the motion of the table is obtained by a small pinion meshing through an idler gear with the rack *J* which is secured to the table. The pinion shaft *K* is so arranged as to make it possible to disengage it from the idler gear *L*. In this way the power feed to the table is entirely disengaged so that the table can be operated by the handwheel at the front of the saddle or the lever at the rear, without operating any of the power feed mechanism which drives the table. The gear-box contains a bevel gear *M*, two bevel clutch pinions *N* and a clutch *O*. Clutch *O* is free to be engaged into clutch teeth on clutch pinion *N* which reverses the motion at its engagement with either one side or the other. Clutch *O* is secured to a shaft which runs through the above mentioned clutch gears, and this shaft carries a bronze bushing *P* that has a double spline, on which the clutch *O* is free to be engaged in the pinion *N* by the lever *Q* which is operated by bellcrank *R* connected to bellcrank *S* by rod *T* operated from the table by lever *U* which, in turn, operates from the table by the dogs *V*. These dogs are carried in a T-slot in the front of the table and are easily adjusted so as to bring the work in the correct position in relation to the grinding wheel, allowing the operator to shorten or lengthen the stroke as desired.

As will be seen, this mechanism is entirely self-contained with none of the working parts exposed to the grindings or dirt, and all of the gears are run in a bath of oil which insures the least possible wear. The eight speed changes obtainable on this machine provide table speeds as follows: 12, 16, 22, 28, 34, 41, 61 and 75 inches per minute. As the power feed on this type of machine is very desirable both for cylindrical and internal work, the utmost care has been taken to equip the Wilmarth & Morman No. 1 universal grinding machines with a simple automatic mechanism.



Boring, Reaming and Facing Machine built by Reed-Prentice Co.

REED-PRENTICE BORING, REAMING AND FACING MACHINE

A special boring, reaming and facing machine built by the Reed-Prentice Co., Worcester, Mass., to ream and face a steel forging used as an engine support in an automobile is illustrated herewith. The work is held in quick-acting clamps mounted on a revolving triangular turret on the carriage. All the operations are automatic, with the exception of placing the work in the machine and indexing the turret. Each time the work-holder revolves 120 degrees, the finished piece at the top is removed and another rough forging is placed in position with little loss of time. There are four spindles. Two pieces of work are operated on simultaneously. The cycle of operations is as follows: The carriage moves to the right and the piece is drilled; the carriage next moves to the left and the piece is reamed; the turret is then indexed by the operator and a new piece is put in; the carriage now moves to the right, and one side of the piece is faced; and the carriage is then moved to the left, and the other side of the piece is faced. A ten-horsepower motor is used to drive the machine.

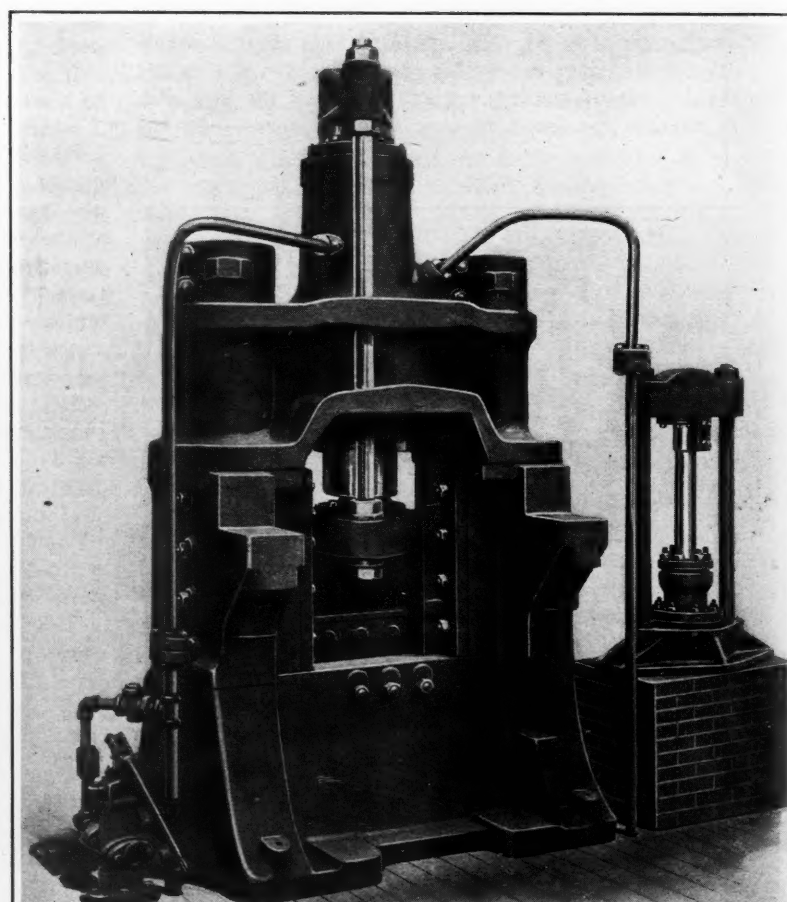
WESTINGHOUSE PORTABLE PANELS FOR ELECTRIC WELDING

An electric welding outfit to be of maximum service should be so arranged that it can be taken to the work no matter where the latter may be located. For instance, in a railroad shop there should be outlets adjacent to each stall in the roundhouse and in various places through the shop. One solution of the problem would be to locate a panel outlet of a suitable type wherever it is anticipated that electric welding might be desired, but this is rather an expensive proposition. The Westinghouse Electric & Mfg. Co., East Pittsburg, Pa., has developed a simple and inexpensive portable outlet panel for electric welding service. Two types of portable outlet panels are furnished, both being mounted on light trucks. They consist of a control panel mounting a handle trip railway type of circuit breaker having overload release with magnetic blow-out, and a 13-point faceplate connected to a resistor mounted in the rear of the panel. The face of the panel is protected by a metal cover through which the handles of the rheostat and circuit breaker project. The Type E panel is intended for metal electrode welding only, having a capacity of from 80 to 170 amperes. With this outfit one metal electrode holder and one shield are supplied. For a wider range of work a Type F panel should be used. This will handle metal electrode work from 80 to 160 amperes, and light graphite electrode work up to 300 amperes. The outfit includes one metal electrode holder, one graphite electrode holder and one mask.

In installing an electric welding system using these portable panels, a Westinghouse arc welding motor-generator set may be placed at some central point. Where suitable, low-resistance ground connection can readily be made throughout the shop, as, for instance, where metal floors or cast-iron bed plates are in general use or in a railway shop where the track system can be used, only one connector need be extended to the various receptacles. The iron floor-plates may be arc welded to each other and isolated sections tied together by an iron rod or heavy copper cable, while the track rails may be bonded by arc welding the fish plates to the rails. Receptacles should be provided throughout the shop of a capacity appropriate for the service for which they are intended. These receptacles may readily be mounted out of doors if they are provided with protection from the weather. Only single-pole receptacles and a single wire cable to the portable panel need be provided. The flexible cable leading from the panel to the electrode holder should be as short as is consistent with the class of work to be done. Where metal floors or tracks are not available, the ordinary two-wire system of distribution with double-pole outlets and two-wire cables should be provided.

SOUTHWARK 500-TON BILLET SHEAR

A billet shear of large capacity, intended for cutting hot billets in rolling mills, has recently been brought out by the

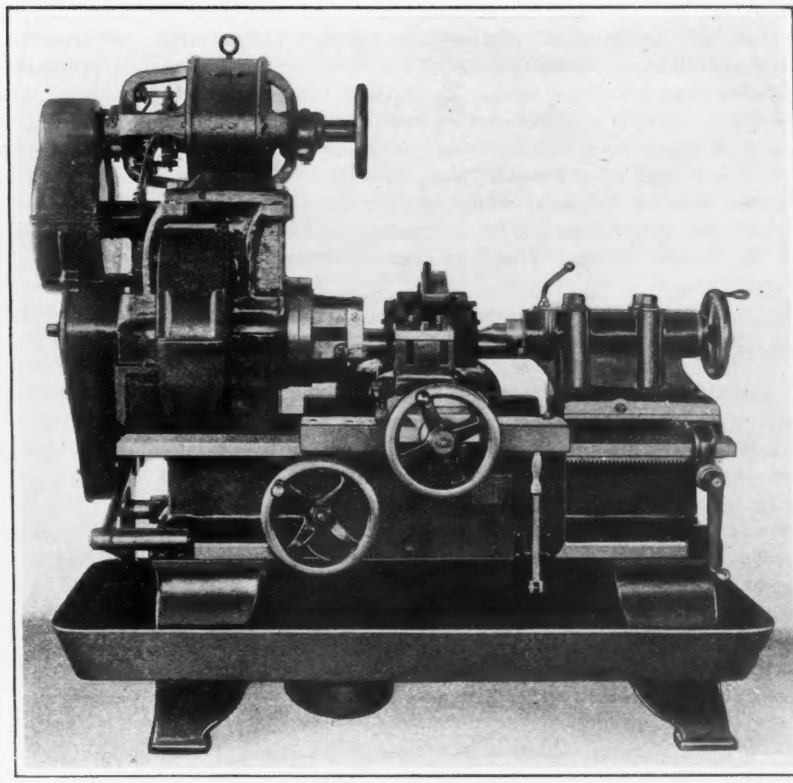


Southwark 500-ton Billet Shear

Southwark Foundry & Machine Co., Philadelphia, Pa. The machine has a capacity for shearing two 6-inch square billets simultaneously, has a knife 24 inches long, and is hydraulically operated, having a 16-inch ram working under 5500 pounds hydraulic pressure supplied by a steam-hydraulic intensifier which is part of the machine. The displacement of the intensifier is sufficient for the 10-inch stroke required for cutting off the billet. On the return stroke, the water in the working cylinder returns to the intensifier and is used over again. In addition, a valve is provided for supplying the slight amount of water which is lost by leakage. The pull-back works under 650 pounds pressure.

The complete control for the cutting of billets is obtained by one lever, which takes care of both the press and intensifier. There are three positions for this lever—when it is raised, the ram will rise also; when it is lowered, the ram will descend; and, in addition, there is a neutral position; when the lever is at this position, the ram will remain at rest.

The whole design of the machine is unusually heavy. The tension bolts, for example, are 12 inches in diameter. An interesting feature in connection with the design of the nuts on the tension bolts is that the latter are split and clamped by smaller bolts, so as to prevent any loosening of the nuts. All castings, except those for the rams, are made from cast steel. The rams are made from close-grained cast iron. The sliding block to which the shear blade is attached is provided with adjustable bronze liners which slide on steel liners on the stationary part. All the rams are outside-packed with flax packing. The total weight of the machine without the intensifier is over 100,000 pounds, and with the intensifier, 140,000 pounds.

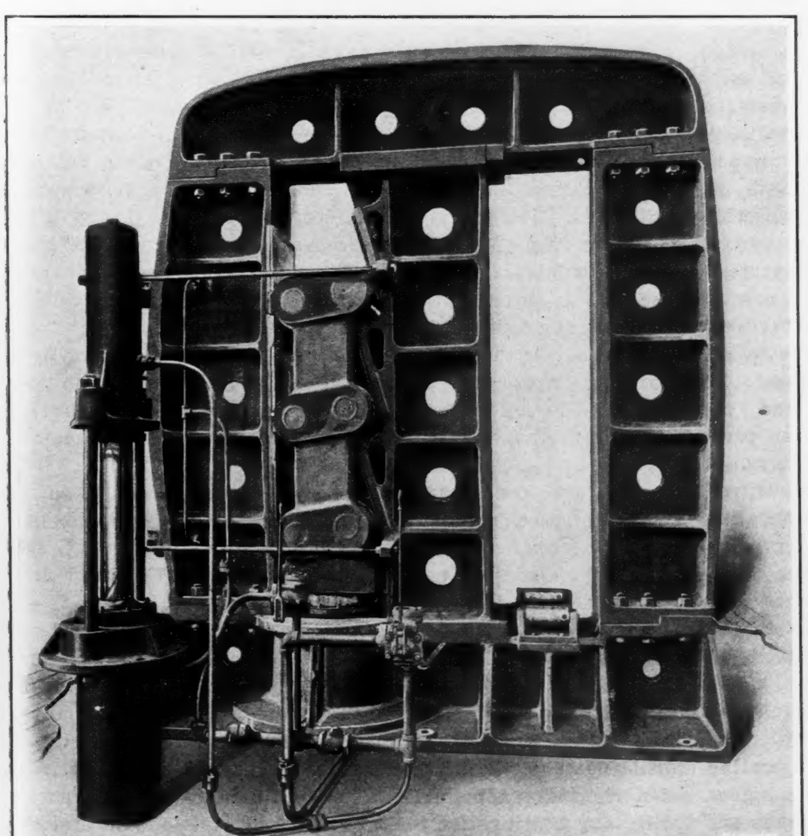


Reed-Prentice Special Crankshaft Flange Turning Lathe

REED-PRENTICE CRANKSHAFT FLANGE TURNING LATHE

This is a special-purpose machine designed to turn and face the flywheel flange of a crankshaft. The spindle is a large iron casting with a 7-inch hole through its entire length. Properly located in this hollow spindle is a positive dead center to support the front end of the crankshaft. So that this center can be located quickly, a cone-shaped piece is pressed into the spindle, which directs the crankshaft onto the center immediately. The shaft is held to the faceplate by an adjustable chuck arrangement which holds the shaft rigidly and accurately. It is clearly shown in the accompanying illustration. The flange end of the crankshaft is supported on a tailstock center. The tailstock is of heavy construction, and is fastened to the bed by four large bolts.

A compound tool-block is fitted to the rest, and three tools are placed in the required positions to turn the flange to its predetermined thickness. These tools face both sides of the flange and turn the fillet at each end of the main bearing. There is a secondary cam-actuated tool-block which turns the outside diameter of the flange while the three other tools are facing. The lathe is a motor-driven machine with the reduction accomplished through heavy gearing. A one-speed and one-feed system is used, as the most advantageous speed and feed has been determined for the work at hand for which the machine was especially designed. This machine is a recent product of the Reed-Prentice Co., Worcester, Mass.



Southwark Vertical Hydraulic Plate Bending Press

SOUTHWARK PLATE BENDING PRESS

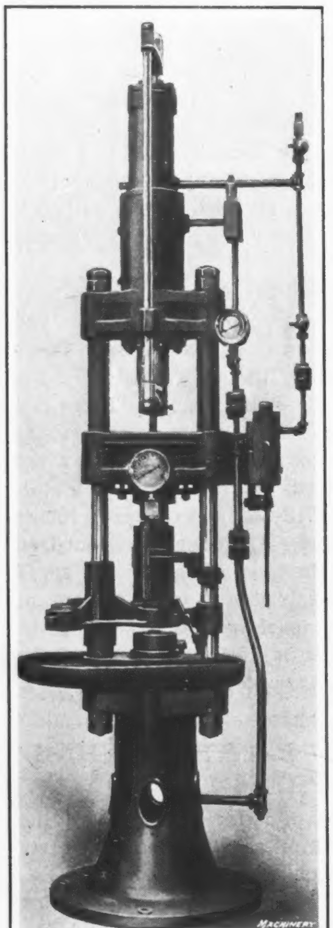
The accompanying illustration shows an improved vertical hydraulic plate bending press built by the Southwark Foundry & Machine Co., Philadelphia, Pa. These presses are now being used by many of the leading marine and stationary boilermakers for bending boiler shells and similar work, and especially when thick plates have to be operated upon, as they bend plates completely up to the end, which cannot be done by rolls; they can also be used for bending the butt straps. These machines will bend plates to a complete circle, as the top tension member can be arranged with a swinging bolt so that the shells can be drawn up from the top. Plates can be bent to a given radius by once

passing through the machine, and unskilled labor can be used, as when the stroke of the ram is once adjusted the required curve will be given independently of the operator.

One of these machines having an inclined plane and roller arrangement needs a much smaller ram than if working direct; it is therefore much more economical to work, a saving of fifty per cent of the water used being effected. The advantages claimed for these machines over rolls are economy in work and power, and the requirement of less space. They can be erected at any place without considering driving arrangements.

SOUTHWARK SHELL TESTING PRESS

To meet the demands of the United States specifications for common steel shells, the Southwark Foundry & Machine Co., Philadelphia, Pa., has developed a complete line of hydrostatic shell testing presses. The general arrangement of these machines is as illustrated herewith. Owing to the fact that each type and size of shell requires a different test pressure, it was found necessary to develop two basic designs, to which modifications have been made to provide a machine for each particular type of shell. The machine illustrated herewith is for testing 75-millimeter (3-inch) shells. As will be noted, the machine is purely hydraulic in its operation, is of the two- or three-column type, and has a revolving table suitably indexed, so that when one shell is being subjected to the hydrostatic test pressure (the maximum in the case of the 75-millimeter shell being 18,000 pounds), a second shell has been revolved into a convenient position for inspection, while a third shell is being filled with water in readiness for the test.



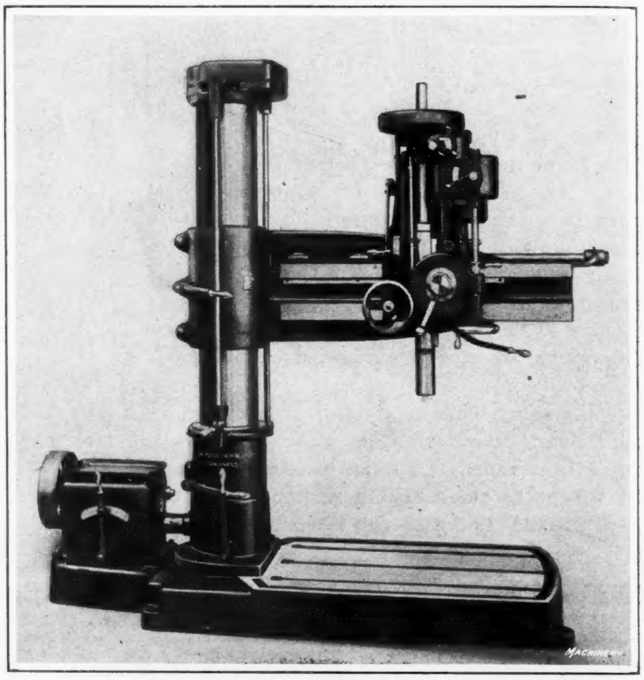
Southwark Hydrostatic Shell Testing Press

The capacity of this machine, under ordinary working conditions, is about 120 shells per hour. Its operation may be briefly described as follows: The first movement of the single lever operating valve admits the line pressure 1500 pounds to the lower cylinder. This cylinder, moving upward, engages the slotted base-plug in the revolving table and forces the open end of the shell nose into an ingenious sealing gland. When the full pressure on the lower cylinder has been reached, the line pressure is automatically admitted to the top cylinder, which is arranged with an intensifier ram projecting through a suitably packed gland in the stationary cross-member into the open nose of the shell, which, having been previously filled with water, acts as the high-pressure intensifier cylinder, and the pressure is instantaneously raised to the predetermined amount. This pressure is read from a gage communicating with the chamber intervening between the circular shell nose and the intensifier ram.

The same principle applies in general to machines for the 4.7-inch, 6-inch, 8-inch, 9.5-inch and larger shells. From this it will be noted that the high pressure of the test is developed only in the body of the shell; all other parts of the machine, including the operating valves, piping and the cylinders, are never subject to a higher pressure than the extremely nominal one of 1500 pounds per square inch. The entire action of the machine is controlled from a single lever operating valve, insuring rapidity of action and proper sequence of movements. All machines have been designed so that they will develop at 1500 pounds line pressure a pressure in the shell body equivalent to within 5 per cent of the elastic limit of the metal. In this way, by decreasing the line pressure, the machine is applicable to any change in pressure which our government may deem desirable to make at some future date.

MORRIS PLAIN RADIAL DRILLING MACHINE

The illustration shows a plain radial drilling machine with speed-box drive, which is built in 4- and 4½-foot sizes by the Morris Machine Tool Co., Court and Harriet Sts., Cincinnati, Ohio. This drilling machine can also be arranged for cone pulley drive, constant-speed motor drive in connection with speed-box, or for variable-speed motor drive. The arm slides up and down on a column by power, with safety stops in the extreme positions, and the column swings around a stump that runs through to the top of the column. At the top of the stump a combination annular and thrust ball bearing is mounted, which carries the entire weight of the column and arm. At the bottom of the column there is a plain bearing on the stump. This construction permits the arm to swing with ease. The stump is securely mounted on a heavy base, which is deep and well ribbed. Around the edge of the base there is a lubricating channel which drains to a reservoir, and the base is so arranged that the oil-pump and piping can be attached at any time.



Plain Radial Drilling Machine built in 4- and 4½-foot Sizes by the Morris Machine Tool Co.

The lever at the bottom of the stump, standing in a vertical position, controls the friction clutches on the pulley shaft in the speed-box. This lever, which is convenient to the operator, when in the neutral position stops every gear on the machine, and in connection with the double back-gear lever on the head, the operator can secure any of six spindle speeds instantly. With the speed-box, eighteen spindle speeds are available, and on the cone pulley drive there are fifteen spindle speeds. The double back-gear is mounted at the back of the head and is fully enclosed.

Back-gear clutches and clash gears are made of nickel steel, heat-treated and hardened. Tapping attachment miter gears are also mounted back of the head and are enclosed in an oil-tight case and run in oil. Frictions are of the expanding ring type capable of pulling the maximum capacity of the drill and controlled from the front of the machine. The friction rings are adjustable. The head is heavily constructed with long bearings for the spindle. It travels on the arm on wide bearings by means of a handwheel, movement being through reduction gears to a rack and pinion. The spindle

is equipped with a ball thrust bearing, and the bearings throughout are lined with bronze and provided with felt wipers. A recess around the bearing acts as an oil reservoir.

Through the feed gear box mounted on the head, six rates of feed are obtainable. A direct reading depth gage is provided, arranged to throw the feed out; and a safety feed throwout is arranged at the end of the spindle travel. All gears are of steel except the spindle gear, which is semi-steel, made of a one-third scrap steel mixture. The speed-box is fully enclosed and gears run in heavy oil. A tool tray is mounted on top of the box, and a speed plate is furnished, giving the operator all spindle speeds at certain positions of the lever.

The principal dimensions of this machine are as follows: drills to center of circle, 8 feet, 6 inches in diameter; maximum distance from spindle to base, 60 inches; minimum distance from spindle to base, 10 inches; maximum distance from spindle to table, 39 inches; maximum spindle traverse, 16 inches; diameter of spindle above sleeve, 1 15/16 inch; spindle taper, No. 5 Morse; range of spindle speeds with cone pulley drive, 19 to 350 R.P.M.; range of speeds with speed-box drive, 20 to 350 R.P.M.; speed of countershaft with cone drive, 400 R.P.M.; size of tight and loose pulleys, 14 inches in diameter by $4\frac{1}{4}$ inches face width; size of single pulley for speed-box drive, 14 inches in diameter by $3\frac{3}{4}$ inches face width; speed of pulley for speed-box drive, 400 R.P.M.; size of working surface of base, 36 by 51 inches; size of working surface of table, 18 by 24 inches; diameter of column, $11\frac{1}{4}$ inches; over-all height with arm and spindle in highest position, $120\frac{1}{2}$ inches; power required for motor drive, 5 horsepower; ratio of variable speed motor, 4 to 1; and weight of machine crated, approximately 7500 pounds.

REED-PRENTICE BRASS DRILLING MACHINE

The four spindles of this machine are driven by hardened steel spiral gears running in an oil bath, and the gears are equipped with ball bearings. All spindles are adjustable, and

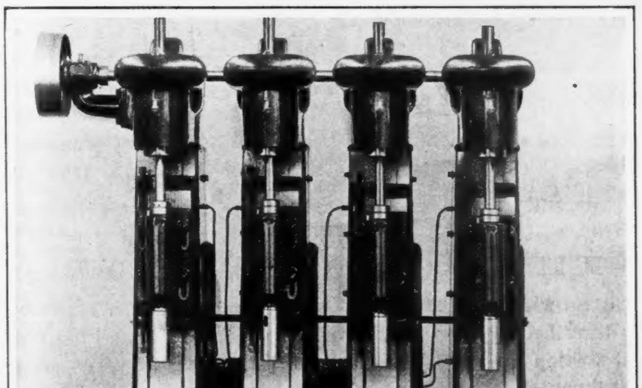


Fig. 1. Four-spindle Reed-Prentice Brass Drilling Machine

any one may be worked independently of the others. The feed for each spindle is self-contained, a cam being mounted with ball thrust bearings in each post, driven by a hardened steel worm and phosphor-bronze worm-gear running in oil. After the cam has made its cycle, the feed is automatically stopped by a rod disengaging the worm-gear clutch. The starting device is arranged so that by a slight pressure from the operator's knee the clutch is engaged immediately. This is a saving of time, when it is considered that the spindle revolves 770 R.P.M. and the cam makes a cycle every 77 revolutions of the spindle. The rate of feed is 0.078 inch per revolution. Both speeds and feeds can be easily changed.

The work is held in a three-jawed chuck and at the end of the operation is allowed to fall through into a chute. The bottom of the chute is perforated to allow the chips to fall through into one pan, while the work is collected in another.

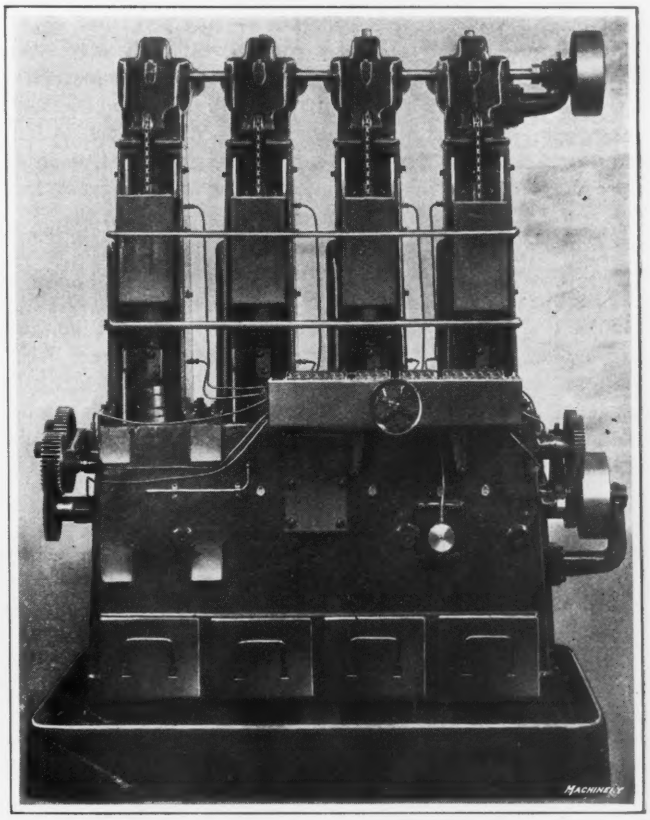


Fig. 2. Opposite Side of Brass Drilling Machine shown in Fig. 1

The motor is mounted on the back of the machine driving through gears. A Detroit force-feed oiler mounted on the back of the machine lubricates the twenty-two principal bearings, while the lubrication of the less important ones has been adequately taken care of. All gears are properly guarded. This machine is built by the Reed-Prentice Co., of Worcester, Mass.

The principal dimensions of this machine are as follows: size of spindle bearing in head, 1 7/16 inch in diameter by 10 inches long; size of spindle bearing in branch head, 1 1/4 inch in diameter by 10 1/2 inches long; taper of hole in spindle, No. 4 Morse; maximum travel of spindle, 6 inches; distance between spindles, 13 inches; power developed by motor, 3 1/2 horsepower; over-all height of machine, 88 inches; spindle speed, 770 R.P.M.; spindle feed per revolution, 0.078 inch; and floor space occupied by machine, 46 by 73 inches.

SIDNEY POWER PRESS

The Sidney Power Press Co., Sidney, Ohio, is now building a line of open-back inclinable power presses ranging in size from No. 1 to No. 6, and in weight from 1000 to 6000 pounds. Although these machines represent no radical departure from ordinary power press construction, their design has been worked out to incorporate the most up-to-date features of machines of this type. In addition, all Sidney presses are equipped with an automatic safety clutch, which insures the combined features of positive action and safety for the operator.

PERSONS-ARTER MAGNETIC CHUCK

The Persons-Arter Machine Co., 72 Commercial St., Worcester, Mass., has recently completed what is believed to be the

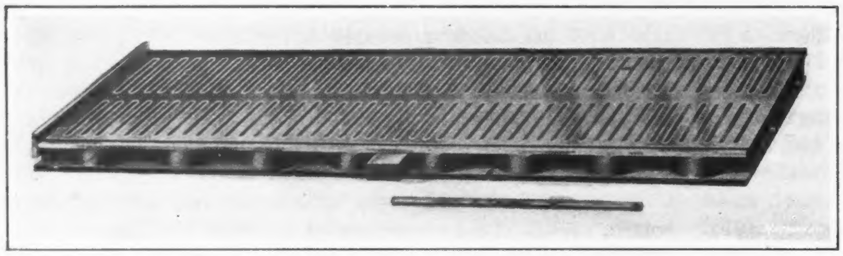


Fig. 1. Persons-Arter Magnetic Chuck 100 Inches Long and 25 Inches Wide

largest magnetic chuck ever built for holding precision work. This chuck was built especially for the Simonds Mfg Co., Fitchburg, Mass., for use on a large grinding machine recently designed and built by that company. Fig. 1 shows the finished chuck ready for mounting on its machine. This chuck is 100 inches long, 25 inches wide and 5 inches deep, and an idea of its size may be gathered by comparison with the yard stick shown with it. It has a pulling capacity approaching 250 pounds per square inch and is magnetically alive all over its face, making every square inch available for the holding of work.

In building the chuck, advantage was taken of the adaptability for such a purpose of the Persons-Arter rectangular chuck units, that is, four standard size individual chucks were used in the making of this large chuck, each individual chuck being constructed of standard units. Fig. 2 shows the units used, including the polar shell, the polar core and the coil for magnetizing the shell and core. Each chuck section is composed of one shell, four cores and four coils, all being interchangeable and readily replaceable. Almost any size of chuck desired can readily be supplied by using standard sized units in multiple. This method greatly lessens the necessity of carrying a great amount of various sized chuck parts in stock and insures quick delivery, as requirements can be met without any special work being entailed.

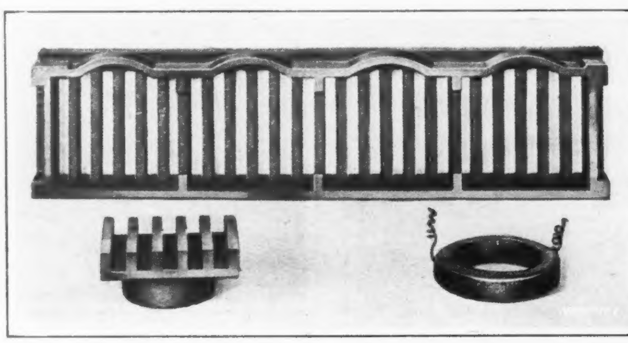


Fig. 2. Units used in Construction of Persons-Arter Magnetic Chuck

The chuck face has been designed to secure a large amount of magnetic edge and a high holding capacity for all classes of work, whether large or small. In building the circular form of chuck made by this company, a special design was evolved, *viz.*, radiating arms to and from the center with interlocking concentric arms. It is a well-known fact that the greater the magnetic edge, the greater the holding capacity of the chuck; therefore, when considering the magnetic face alone, it is necessary in obtaining the greatest holding effect to provide the greatest length of magnetic edge for the least enclosed area. In the rectangular type chucks, this is a simple matter, as it is only necessary to produce a series of narrow magnet poles running right across the chuck face (the narrower, the better, within practical limits). It is obvious that any divergence from a plain narrow rectangular shape would mean less magnetic edge for a given enclosed area and less magnetic effect.

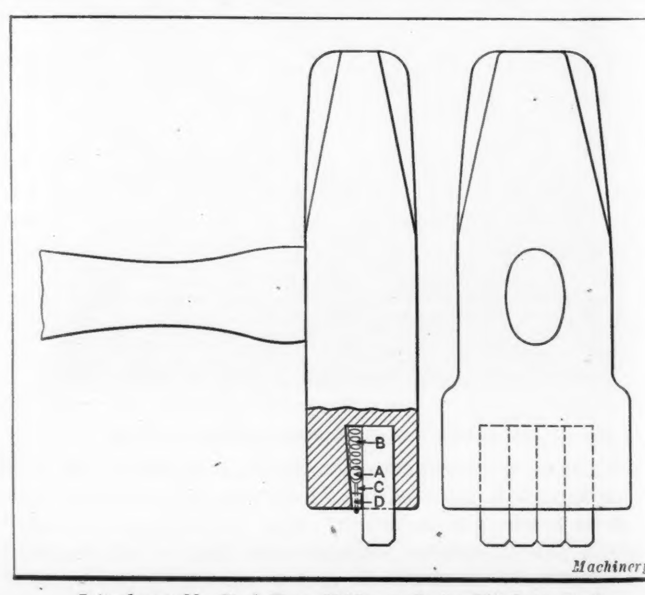
When, however, we consider the electrical magnetizing force, or the magnetic coil, the conditions are the opposite to those of the magnetic face. Thus to produce the greatest efficiency it is necessary to enclose the greatest area for the least periphery. It is a well-known fact that a greater magnetizing force can be obtained by using a circular coil with a given electrical power than by any other shape of coil; and the more the shape of the coil diverges from a circle, the less the magnetizing force for a given electrical power consumption.

The problem, therefore, was how to obtain the two opposite conditions and secure the greatest magnetic face and the greatest electrical magnetizing force at the same time. By using a core of the shape shown in Fig. 2, it is claimed that the necessary conditions were obtained. This comprises a circular core body, having a distributing plate at the top, from which emanate the narrow pole strips, all made integral, to interlock with those of the polar shell. Not only does this shape meet the above conditions, but it provides another important feature in leaving only a very narrow space between the walls of the polar shell and the distribution plate. The importance of this is apparent when considering the question of filling in between the poles with white metal. Only a narrow space is left between the shell and core, and it is an easy matter to calk this space and make an absolutely water-tight joint. After the coils are assembled, all open spaces are filled with a high-grade insulating and water-proofing compound, making it impossible for water or foreign matter to get near the coils.

The material of which the chuck is made is another fact of great importance. A metal with a high permeability is absolutely desirable. Gray iron is out of the question, and a soft steel is probably the only solution. All the chuck parts comprising the magnetic circuit are, therefore, made of a soft steel of high permeability; an electric furnace product, equal in quality to Swedish or Lancashire iron, is sometimes used for chucks. This means that a greater number of magnetic lines of force per unit area are obtained for a given magnetizing force than would be if some other material were used. By carefully following these details, the results have been all that could be expected. The chuck is powerful, is economical in the consumption of electrical power, and has a liberal sized magnetic area. On this 100- by 25-inch chuck, as well as on all Persons-Arter chucks, the bottom plate is made in one piece, and on large rectangular chucks hexagon head bolts are used to bind the plate to the chuck body. Therefore, a large size wrench can be used and the plate securely fastened to the chuck body, thus insuring freedom from water entering the chuck. The rectangular chuck rests on a number of non-magnetic supporting feet, which insulate the chuck from the machine bed and also provide a clear path underneath for the cutting compound to flow. These feet also make it an easy matter to true the chuck in position.

PITTSBURG STEEL TYPE HOLDER

The interchangeable steel type holder which is illustrated and described herewith, is a recent product of the Pittsburg Steel Stamp Co., 316 Penn Ave., Pittsburg, Pa. The chief advantages claimed for this device are as follows: It does



Interchangeable Steel Type Holder made by Pittsburg Steel Stamp Co.

not require grooved type, and as a result is equally efficient for holding all kinds of grooved and straight type. The claim is also made that it is the only holder which will carry ungrooved type on heavy stamping, and a further advantage is that type can be quickly changed. No strain is imposed upon the gripping members. A hole, the side of which opens into the socket for the type, runs at an angle as shown in the partial cross-sectional view. A steel ball *A* backed up by a spring *B* is carried in this hole. When the type is pushed into the socket in the holder, the ball is forced upward against the spring tension; and when the type has been put into place, the spring forces this ball down between the type and the inclined side of the hole, thus preventing the type from falling out. A pin *C* held by a light bushing *D* is used to push up the ball when it is required to change the type. This interchangeable steel type holder was developed by E. T. Hudspeth, tool-room foreman of the Pittsburg Steel Stamp Co.

NEW MACHINERY AND TOOLS NOTES

Seam-welding Machine: Thomson Electric Welding Co., Lynn, Mass. A line of four electric seam-welding machines which are for welding material up to sixteen gage. These machines are known as Nos. 306, 312, 318 and 324, and are of sizes to permit work to be handled up to 6, 12, 18 and 24 inches in length, respectively.

Bench Grinding Stand: Luther Grinder Mfg. Co., 289 S. Water St., Milwaukee, Wis. A No. 306 power grinding stand adapted for the use of grinding wheels 6 inches in diameter by 1⅜ inch face width. The machine is built with bearings of ample size to assure smooth operation, and it is adapted for mounting on a bench or heavy table; it weighs 15 pounds.

Ratchet Tap Wrench: Moss-Ochs Co., 3387 E. 116th St., Cleveland, Ohio. A ratchet tap wrench made in two sizes, namely, a No. 1 wrench with a capacity up to ¼ inch and a No. 2 wrench with a capacity from ¼ to ½ inch. This wrench is furnished with a T-handle which is made a sliding fit to permit of operation in corners or other places where the space is limited.

Six-spindle Vertical Lathe: Bullard Machine Tool Co., Bridgeport, Conn. An automatic vertical lathe which comprises six independent lathes arranged in a circle and five tool-heads. This machine is built in two types, *viz.*, a universal type, facing, boring and turning to any angle; and a compound type, facing, boring and turning in vertical and horizontal directions only.

Gas Furnaces: Capital Die, Tool & Machine Co., Columbus, Ohio. A line of "Ever-Ready" gas furnaces which are operated without a blower and are claimed to be economical in gas consumption. They are made in a number of different sizes ranging from 4 by 6 by 12 inches with a gas consumption of 30 cubic feet per hour, up to 6 by 12 by 20 inches with a gas consumption of 90 cubic feet per hour.

Elevating Truck: Holyoke Truck Co., Holyoke, Mass. A Type RL-10 truck which has a capacity for handling loads up to 5000 pounds. The truck platform is 40 inches in length and the extreme width of the truck is 27 inches; the height with the platform lowered is 10 inches and the platform may be raised a distance of 2 inches. This truck has two closely spaced wheels at the front and two wheels at the rear.

Blueprint and Drawing Holder: National Co., 273 Congress St., Boston, Mass. A holder for blueprints, drawings, charts, etc., which is furnished with a top strip or binder that secures the sheets onto the holder. This top strip is removed by means of catches which may be quickly operated. Three catches are used so that provision is made for holding narrow prints. These holders are made in three sizes of 30, 36 and 42 inches in length.

Shell Trimmer: De Mant Tool & Machine Co., 79 E. 130th St., New York City. A semi-automatic shell trimmer which is adjustable for trimming shells from 1/4 to 2 inches in length and from 1/16 to 1/2 inch in diameter. The toolpost is designed to permit positive operation with a minimum effort, and a release lever ejects the finished work without the necessity of stopping the machine. Shells may also be fed while the machine is running.

Blow Torch: Naab Mfg. Co., Cleveland, Ohio. A blow torch which operates with either natural or illuminating gas and which is designed to produce high temperatures by employing a pressure fan which is integral with the torch to provide for mixing gas and air ready for combustion. This apparatus consists primarily of a portable gas torch which is entirely self-contained; the pressure fan is attached directly to the burner, thus tending to eliminate any air leakage.

Drilling Machine Turret Head: Spafford Tool Works, 10 Hoadley Place, Hartford, Conn. A five-spindle turret head for use on single-spindle drilling machines to provide for the performance of a sequence of operations at a single setting of the work. The turret may be moved around either way to bring any spindle into the operating position, regardless of whether the machine is running or at rest. All of the spindles are at rest except the one which is in the operating position.

Expanding Reamers: Cutter & Wood Supply Co., 68-70 Pearl St., Boston, Mass. A line of expanding reamers which are fitted with six adjustable blades, so that a micrometer may be used for setting the reamer to size. Adjustment is made by means of nuts at the ends of the blades that slide in inclined slots. Each reamer will expand from 0.010 to 0.015 inch over its maximum listed size so that provision is made for considerable grinding before new blades are required.

Elevating Truck: Lewis-Shepard Co., 48 Binford St., Boston, Mass. In the November number of MACHINERY a description was published of a Type L truck built by this company for carrying loads up to 2500 pounds. Recently, the same firm has added to its line a Type K truck which is of the same general design, except that it has a capacity for handling loads up to 8000 pounds. For a full description and illustration of the Lewis-Shepard elevating trucks the reader is referred to the November number of MACHINERY.

Shell-heating Furnaces: Electric Furnace Co., Alliance, Ohio. Automatic electric shell-heating furnaces which are especially adapted for the performance of heat-treating operations on shells. They represent an adaptation of furnaces of similar size and design, which have been used for the heat-treatment of steel parts for railway and motor car equipment. The outfit consists essentially of two furnaces, the quenching mechanism and the automatic control by means of which all operations or movements of the shells are accurately timed.

Tool and Cutter Grinder: Woods Engineering Co., Alliance, Ohio. An improved form of the No. 2 universal tool and cutter grinding machine formerly built by this company. The new machine is equipped either for belt drive or with self-contained motor drive. The knee is of box section and entirely encircles the column, sliding on a V-key which is adjustable for wear. Both the elevating and cross-feed screws are furnished with micrometer dials. The head may be swiveled through 180 degrees and is provided with a ⅝-inch clamping nut and graduated column.

Milling and Drilling Machine: Moline Machinery Co., Moline, Ill. A machine designed primarily for the performance of milling and drilling operations on automobile steering knuckles, both operations being performed at a single setting of the work in order to insure proper alignment. This machine is of the continuous-operation, six-station type, and is provided with a revolving table that enables the operator to set up the work while another piece is being operated upon by the cutters. In addition to milling and drilling, other operations of a similar character may be performed.

Truck Platform: McMyler Interstate Co., Cleveland, Ohio. A pressed steel platform for use in connection with hand or power elevating trucks, this type of platform being designed to meet the need for a rigid portable platform which is not excessively heavy. Platforms of this kind are furnished with grooves or ribs which are pressed into the single steel plate to give the required strength and rigidity. Standard sized units are made with inside clearance heights varying from 5½ to 10¾ inches, inside clearance widths from 23½ to 39½ inches, and standard lengths from 24 to 78 inches.

Drilling Machine: Buckeye Tool & Machine Co., New Philadelphia, Ohio. Single-spindle 17-inch vertical drilling machine, with upper half of column in the form of an enlarged D-section and containing the gear-box. There are eighteen spindle speed changes and six feed changes ranging in geometrical progression from 0.006 to 0.048 inch per revolution of the spindle. The crown gear at the upper end of the spindle and the driving pinion are mounted in Hyatt solid race type roller bearings. This machine is equipped with a tapping attachment and automatic trip and depth gage with suitable graduations.

Expanding Mandrel and Tool-holders: H. P. Louden, Sr., Lebanon, Pa. A swinging expansion mandrel adapted for all classes of hollow work, although especially designed for shell finishing. It can be arranged for either a friction or an automatic grip. An advantage claimed for the swinging arrangement is the elimination of energy consumed in lifting the mandrel in and out of the machine. The tool-holders are intended for diamond-point and round-nose tools, respectively, and it is claimed that increased production is secured with these holders as well as an economy in tool steel obtained through the utilization of short pieces of steel.

* * *

The new Quebec Bridge was formally opened to traffic on December 4. The first freight train, composed of sixteen freight cars, one van, and one private car with a total weight of 1245 tons, crossed and recrossed the bridge.

GIDDINGS & LEWIS HORIZONTAL BORING MILL

In the October, 1913, number of MACHINERY, a description was published of the No. 0 horizontal boring, drilling and milling machine built by the Fosdick Machine Tool Co. Recently the Giddings & Lewis Mfg. Co., Fond du Lac, Wis., acquired the manufacturing rights for this machine. After purchasing the drawings, patterns, etc., the Giddings & Lewis Mfg. Co. at once started to prepare for building these machines on a large scale. Many features of the design were revised. There are certain shops which have use for a machine of this type, that require a long traverse for the spindle. The standard traverse is 26 inches, and to materially increase the production and supply this demand, provision was made to build the machine with a double-spindle traverse feed which doubles the standard spindle traverse. This result is obtained by collars on the spindle placed in front of and behind the driving nut portion of the ram. Experience has shown that operators of all types of boring mills frequently fail to know when they have fed the spindle to the end of the rack, and to overcome this trouble, an indicator has been provided that shows the exact travel of the spindle at all times. This indicator is positioned directly before the operator, and in this way prevents an over-feed of the spindle ram, thus eliminating danger of lost time in driving the rack back into mesh with the pinion.

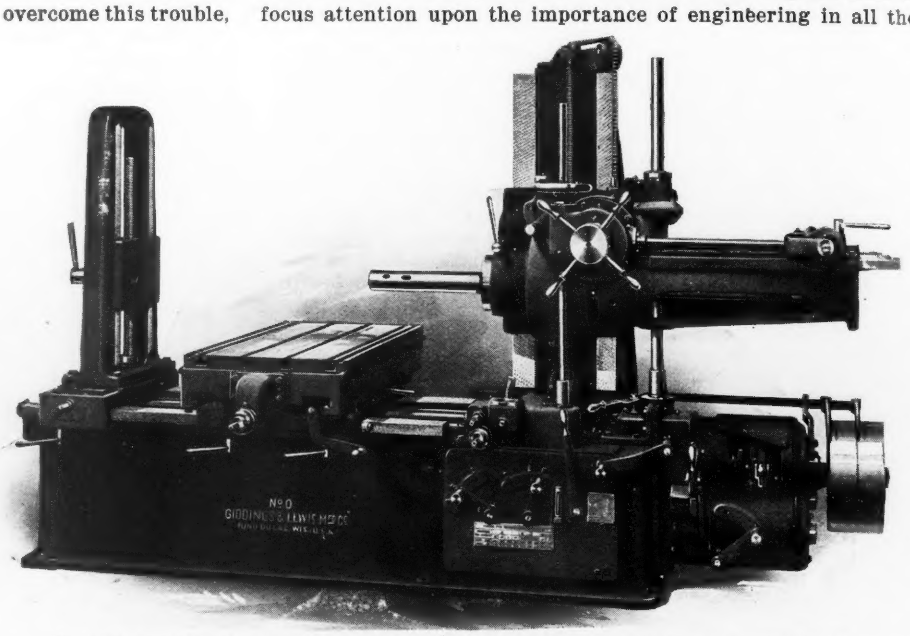
Many small changes have been made in the general design of the machine to assure additional rigidity and to simplify both the operation of the machine and machining operations involved in its manufacture. Changes have been made in the design to provide a perfect support for all moving parts and to afford efficient lubrication of all bearings. The internal gears run in oil, so that they are thoroughly lubricated at all times; and an indicator placed at the front of the machine shows the level of the oil in the case, which is a feature that not only adds to the life of the machine, but eliminates wear and aids in the production of accurate work by the machine. To avoid the probability of costly shutdowns of the machines while in operation, due to carelessness on the part of the operator, "fool-proof" safety devices have been provided on all feed movements. The gearing is so designed that the machine is started at a slow rate, and when the desired rate is selected and engaged, a disastrous shock is prevented because the load is already in movement. Two feeds cannot be engaged at the same time; each separate feed is selected by one lever. The single clutch lever is supplied with a spring latch, making it impossible for the clutch to accidentally engage. The same lever controls the rapid traverse friction and has a spring release, causing the friction to be released as soon as pressure is removed. The location of several of the operating levers has been changed so that the entire control is centralized at the operating position, making it possible to secure maximum results from the machine.

* * *

During December, the War Department took control of the plants of the General Vehicle Co. and the Stewart-Warner Speedometer Co. in Long Island City. Colonel George Montgomery, in command of the Frankford Arsenal, Philadelphia, Pa., will have charge of both plants. These plants are among the most modern and best equipped in Long Island City. It is said that the Stewart-Warner plant, which has not been occupied, will be used for the manufacture of gas masks and other articles used by the soldiers in France. The other plant, which has been manufacturing Gnome motors for about a year, will be devoted to the manufacture of airplane motors and other parts.

CLOSER COOPERATION OF ENGINEERING SOCIETIES

The removal of the American Society of Civil Engineers from its former home on 57th St., New York City, to new quarters in the Engineering Societies' Building, into which they were formally welcomed in conjunction with the annual convention of the American Society of Mechanical Engineers on December 7, marks an interesting epoch in the history of American engineering societies, as now all the national engineering associations—the civil, mechanical, electrical, and mining—are housed under one roof. It is believed that the four national societies will henceforth be able to do greater things because of the strength they will derive from closer cooperation. The union of the societies under one roof is a symbol of the movement toward unity in the engineering profession which has become more pronounced during recent years. The Engineering Societies' Building, at 29 W. 39th St., New York City, is now truly the center of engineering activities in the United States, and as the war has done a great deal to focus attention upon the importance of engineering in all the activities of civilized life, this is an opportune time for an amalgamation of the engineering societies.



No. 0 Horizontal Boring, Drilling and Milling Machine built by the Giddings & Lewis Mfg. Co.

* * *

TEMPERLESS COLLETS

It is one thing to do a difficult job well and another to avoid the necessity of doing it at all. An example in point is the collets used in screw machines designed for handling large work. Collets as ordinarily made must have a spring temper in sections back of the jaws, in order that they will open and release the work when the sleeve is withdrawn. If the collet fingers are not properly tempered, there will be trouble. If too hard, the fingers will break; and if too soft, they will lose their springiness and refuse to release the work, thus causing the operator trouble and delay.

One machine tool manufacturer was clever enough to recognize this defect of spring collets and succeeded in devising a collet chuck that is positively operated both when closing the jaws on the work and when releasing them. His collets are left soft in the thin parts and hardened only in the jaws. The difference in cost on large collets is an important item. Out of several hundred collets made for 9.2-inch British shells, not one was lost in the heat-treating, because the vital and delicate portion was left as it came from the machine—thus we have a case of avoiding trouble rather than correcting it.

* * *

The executive committees of the Master Car Builders' and American Railway Master Mechanics' Associations have decided to abandon the annual conventions for 1918 similarly as was done in 1917. The Railway Supply Manufacturers' Association has also announced that the annual exhibition of appliances is postponed.

COMPARISON OF FORGE, OXY-ACETYLENE AND ELECTRIC WELDING

ESSENTIAL FACTORS IN FORGE-WELDING AND THEIR IMPORTANCE IN THE OTHER PROCESSES

BY H. JAMES

THE old method of welding in a forge fire, where so many variables tend to produce poor work, is being superseded on certain classes of work by the electric and oxy-acetylene processes. Successful forge-welding is dependent on a correct analysis of the material, method of joining the work, fuel, blast pressure, quality of flux and ability of operator. Other important factors are the cost of labor and material. The fuel supplied by the purchasing department is sometimes bought irrespective of analysis. A few analyses will show what is required, and in the case of coal with which the smiths claim that good work cannot be done, it will be noted that the principal difference is in the ash content and the number of British thermal units. Why these slight variations should cause any material difference is hard to explain, but a piece of work unsuccessfully welded in a fire using "bad coal" can be successfully welded in a fire using "good coal." Sulphur is not considered as objectionable in coal today as formerly, but the less there is of it the better. The analyses of smithing coals are given in Table 1.

TABLE 1. ANALYSES OF SMITHING COAL

Brand	Moisture	Volatile Combustible Matter	Volatile Matter	Total Combustible Matter	Fixed Carbon	Ash	Coke	Sulphur	B.T.U.
Logan	0.64	18.18	18.82	91.18	73.00	8.18	81.18	2.82	14,170
Georges Creek	0.30	18.80	19.10	91.95	73.15	7.75	80.09	1.09	14,504
Good Coal	0.34	19.66	20.00	89.21	69.55	10.45	80.00	0.89	14,033
Bad Coal	0.25	18.90	19.15	86.80	67.90	12.95	80.85	1.03	13,404

Machinery

One of the disadvantages of forge-welding is that regulation of the blast is difficult, and perfect combustion is never realized. Besides, the oxidizing influences that are present tend to produce a poor weld. The flux used is generally borax or sand; but very little is used, and in large shops the welding is done at a high temperature, which results in coarsening the grain. The work is then annealed to restore the grain. If it were not for this high temperature, the welds would be considerably poorer.

That there is considerable variation in the strength of welds is well known. A comparison of results from varied sources shows that the ratio of the strength of welds to the strength of solid pieces, in the case of iron, varies from 60 to 85 per cent, and from 55 to 85 per cent in the case of steel. Chain welding, which is probably the most exact work done, varies from 72 to 95 per cent.

Tests on the safe ending of boiler tubes give a good idea of the erratic results one may expect to find in practice. The point to be settled in the tests was the feasibility of welding the Parksburg iron safe ends onto steel tubes supplied by the National Tube Co. In the first test, Parksburg iron safe ends were welded onto Parksburg iron tubes; in the second test, the five iron ends were welded onto National Tube Co.'s steel tubes; and in the third test, steel ends were welded onto the steel tubes. In all cases, the tubes were two inches in diameter and the tensile tests were on eighteen-inch lengths.

Test No. 1

Sample	Heat	Appearance	Tensile Strength, Pounds
1	Bright yellow		
2	Bright yellow, plus	Good	30,040
3	Bright yellow	Poor	28,390
4	Very bright yellow	Very good	31,730
5	White	Fair	27,440

The foreman said that the first three samples were not hot enough, but the smith contended that the second sample was. The first, second and fourth samples broke at the weld, but did not pull apart.

Test No. 2

Sample	Heat	Appearance	Tensile Strength, Pounds
A	Bright yellow	Good	26,810
B	Bright yellow	Very good	28,280
C	Bright yellow	Very good	26,920
D	Bright yellow	Very good	31,440
E	Bright yellow	Fair	23,860

The first four samples broke at the weld, but did not pull out; the fifth broke back on the steel tube about one inch from the weld, at a point where it was overheated.

Test No. 3

Sample	Heat	Appearance	Tensile Strength, Pounds
1	Very bright red	Good	28,220
2	Very bright red	Good	30,980
3	Very bright red	Poor	31,590
4	Very bright red	Poor	25,400
5	Bright yellow	Good	29,450
6	White	Fair	19,280

The first four samples pulled apart at the weld; the fifth and sixth were burned; the last sample broke back on the tube about one inch, where it was overheated.

The labor element is also an important factor in the making of a successful weld. Even in a well organized, up-to-date shop the writer has seen two smiths, working on large work at separate fires, draw the work, knock off the clinker, rush to the hammer a few feet away, and find the hammer boy far down the shop wrestling with a friend. Then after the piece was welded and the men thought a good job was done, they found that the weld practically fell to pieces.

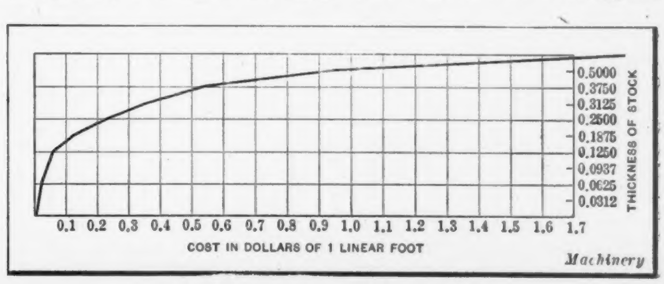
Oxy-acetylene Welding

When welding with acetylene, the analysis of the material is known because this method is generally used on parts that have failed in service. Generally, also, the quality is determined; in any case, the difference between iron and steel is not so noticeable. The material used to make the weld is purchased in the correct form and to the right analysis. The blast pressure is registered by a gage, so that there is less danger of oxidation, and the quantity of acetylene is regulated. A flux is nearly always used, though its composition may vary considerably, as is here shown:

Analyses of Fluxes

	Per Cent
Borax	57.35 to 33.79
Calcium carbonate	6.47 to 38.16
Siliceous matter	33.03 to 1.06
Carbon	3.15 to 26.99

In acetylene or electric welding, the operator generally does little else, whereas a smith may do several other kinds of work, and the old saying that practice makes perfect holds good. An intelligent handy-man is generally employed, and his wages are a trifle less than a smith's. The cost of material, which includes gas, is greater, however, than when the welding is done in the forge fire. The cost of welding in-



Cost of Oxy-acetylene Welding per Hour

TABLE 2. RESULTS OBTAINED WITH ELECTRIC WELDING AND OXY-ACETYLENE WELDING

Method	Breaking Strength, Pounds	Original Strength of Material, Pounds	Efficiency of Weld, Per Cent	Thickness at Weld, Inch	Thickness of Material, Inch	Remarks
Electric	19,420	24,700	78	0.306	0.508	Ground joint
Electric	23,790	24,700	96	0.315	0.513	Ground joint
Electric	25,530	24,700	100	0.324	0.580	Not ground, broke 2½ inches from weld
Electric	24,230	24,700	100	0.317	0.621	Not ground, broke 2½ inches from weld
Electric	24,350	24,700	100	0.322	0.625	Not ground, broke 2½ inches from weld
Oxy-acetylene	17,120	24,590	69	0.305	0.305	Ground joint, broke at weld
Oxy-acetylene	22,690	24,590	92	0.311	0.311	Ground joint, broke at weld
Oxy-acetylene	22,520	24,590	92	0.317	0.418	Not ground, broke at weld
Oxy-acetylene	24,590	24,590	100	0.320	0.463	Not ground, broke 2½ inches from weld
Oxy-acetylene	22,900	24,590	93	0.320	0.359	Not ground, broke at weld
Oxy-acetylene	19,900	24,580	81	0.328	0.415	Not ground, broke through weld
Oxy-acetylene	21,520	24,580	88	0.317	0.390	Not ground, broke through weld
Oxy-acetylene	19,610	24,580	80	0.312	0.420	Not ground, broke through weld
Oxy-acetylene	23,890	24,580	97	0.318	0.385	Not ground, broke through weld
Oxy-acetylene	22,410	24,590	91	0.334	0.415	Not ground, broke through weld
Oxy-acetylene	13,590	21,500	63	0.279	0.337	Not ground, broke through weld

Machinery

creases with the thickness of the work, as the consumption of gas naturally increases with the cross-section of the work. This is indicated in the accompanying chart, which shows the cost of one linear foot of welding for stock varying from 0.03 to 0.5 inch in thickness.

When welding with acetylene, it is necessary to preheat the surrounding parts, as the sudden expansion due to the great temperature of the gas is likely to cause rupture, particularly if there are strains in the casting or forging. In forge-welding, conduction and radiation are more gradual, so that this preheating is not necessary; moreover, very intricate castings are not usually forge-welded. In forge-welding, the amount of hot work performed at and continuing until the right temperature is reached is sufficient to reduce the grain size of the metal, but with acetylene welding the work must be annealed. If the weld is poor, failure will undoubtedly occur through it. If the metal around the weld is affected by the heat and the work is not annealed, failure will occur adjacent to the weld. If the annealing has been done correctly, failure will occur through the weld, but the tensile results will be higher than those obtained with a poor weld.

Table 2 shows the results obtained by electric welding and oxy-acetylene welding. Table 3 shows the results obtained by these methods and the oxy-hydrogen process as well.

Cast iron, when welded and annealed, often shows considerably less strength after treatment than before. This is because annealing, besides relieving internal strains, causes a molecular rearrangement due to the graphite change. A 1¼-inch square bar tested on 24-inch centers had a strength of 3250 pounds before welding and 3000 pounds afterward. In another test, the strength of the bar was 3350 pounds before welding and 3200 pounds afterward. The welding sticks were high in silicon, about 3 per cent, and the outside was thoroughly cleaned so that no sand or dirt could get into the weld and cause trouble in subsequent machining.

The whole of an intricate piece of material should be preheated before welding, so that any internal strains that may exist will be relieved. This preheating and annealing should, of course, be gradual and the parts treated should be kept away from drafts. It is evident that the nearer a piece can be brought to the welding heat in this treatment the less will be the local expansion, proportionately, and therefore the less will be the strains set up. Preheating or annealing is accomplished by an oil torch or oven, neither of which is as expensive as acetylene gas.

The chief difference in the cost of oxy-acetylene welding and forge-welding appears to be the adaptability of the oxy-acetylene process to the work and the fact that in many cases stripping of a machine is unnecessary. A smith may not be available, but an acetylene apparatus is now quite easily found.

TABLE 3. COMPARISON OF OXY-HYDROGEN, OXY-ACETYLENE, AND ELECTRIC PROCESSES

Process and Treatment	Breaking Strain, Pounds per Square Inch	Percentage of Elongation	Percentage of Reduction of Area
Oxy-hydrogen, original plate, ¼ inch thick	68,400	20.0	....
Oxy-hydrogen, welded	32,300	3.0	....
Oxy-hydrogen, welded	29,800	5.0	....
Oxy-hydrogen, welded and annealed	31,000	3.0	....
Oxy-hydrogen, welded and annealed	41,300	4.5	....
Oxy-acetylene, original plate	68,400	20.0	....
Oxy-acetylene, welded	59,450	7.0	....
Oxy-acetylene, welded	53,300	12.0	....
Oxy-acetylene, welded and annealed	56,900	14.0	....
Oxy-acetylene, original plate	49,100	33.4	64.00
Oxy-acetylene, welded with steel plate	46,900	9.0	....
Oxy-acetylene, welded with iron wire	48,600	13.5	9.40
Oxy-acetylene, cold-rolled shafting, original bar[1]	73,740	19.0	50.99
Oxy-acetylene, welded	36,590	1.5	8.12
Oxy-acetylene, Norway iron, original bar[1]	45,000	43.0[2]	66.42
Oxy-acetylene, Norway iron, welded	36,900	6.5[2]	3.91
Electric weld, original plate	61,150	22.0	....
Electric weld, welded	44,000	6.0	....
Electric weld, welded	37,680	4.0	....
Electric weld, welded and annealed	36,400	....	....

Machinery

[1] All bars machined to original area. [2] Elongation in two inches.

TABLE 4. THERMIT WELDS

	Tensile Strength, Pounds per Square Inch	Percentage of Reduction in Area	Percentage of Elongation in 2 Inches
Fracture coarsely crystalline	50,750	2.60	Not measured
Fracture coarsely crystalline	58,480	4.92	Not measured
Fracture coarsely crystalline	56,800	3.00	2.67
Fracture coarsely crystalline	61,800	....	1.00
Fracture coarsely crystalline	61,000	9.00	5.00

Machinery

Electric and Thermit Welding

Locomotive flue welding is now done extensively by the electric process. A comparison of costs shows that the electric method is cheaper than the acetylene. But as far as putting the tubes in is concerned, both are dearer than setting them by hand. But the service conditions give a greater mileage for the welded tubes. The approximate cost by beading is 7.3 cents per flue; by oxy-acetylene welding, 9.8 cents; by electric welding, 7.7 cents.

Firebox sheets are welded and patched successfully by the electric process without removing the sheets. Taking out the sheets or removing a locomotive frame is costly in time and money. Frames have been welded in place by blacksmiths, but it is a difficult job; the better method is to employ thermit. Thermit has also been used successfully for welding side rods. Ordinarily, when welding a channeled rod the flutes are filled with iron, which is allowed to project over the edges of the break. Holes are sometimes drilled a few inches from the ends of the break; when welding, these holes serve to rivet the work together. The rods, after welding, are annealed but are not refluted, being left solid. In Table 4 are given the results obtained by thermit welding. All the test-pieces were cut from risers. The coarse fracture indicates that this steel could be improved by annealing.

BRIQUETTING OF NON-FERROUS LIGHT METAL SCRAP[1]

METHOD OF BRIQUETTING AND PRESS USED

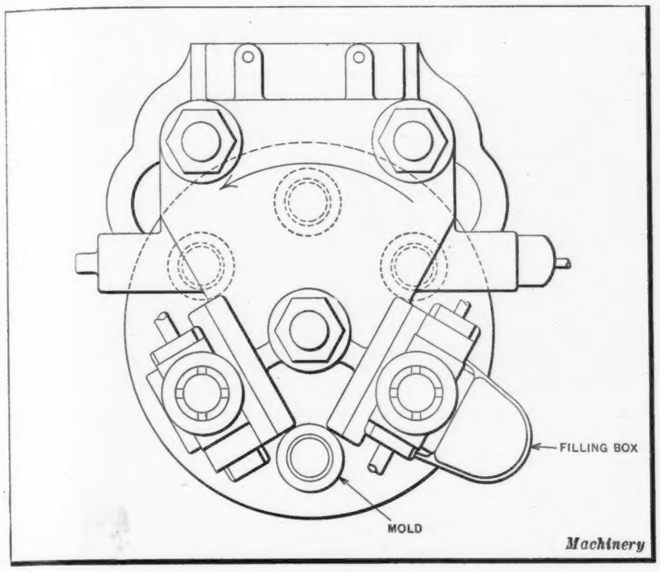


Fig. 1. Plan View of Ronay Briquetting Press

PRICES of metals of all sorts have been subject to rapid advances during the last twelve months, and never before has there been so great a need for rigid economy in metallurgical and melting practice. Ingot metal and heavy scrap have shown a far larger proportional increase in price than have the light scrap, chips and borings. It is evident that if the light scrap can be so treated, or pressed, that it will be cheaply fabricated into a form metallurgically equivalent to the heavy scrap, a great industrial economy will be realized. At present the use of light scrap in the crucibles means a great loss in handling, charging time, and also actual metal losses from burning, oxidation and vaporization.

Bundling or cabbaging, whereby long strips or sheets of metal are pressed into rectangular bundles suitable for melting, has long been an established practice. It is a recognized economy, and bundles are quoted at an advance over the loose scrap. Bundling, as such, is limited to the long, flexible turnings and sheets. Nothing can be done, so far as these cabbaging operations are concerned, with the loose, fine needles, borings, punchings and brass washings. That is the function of metal briquetting. The briquette and the bale are in no sense competitive, at least so far as the non-ferrous metals are concerned, for the reason that they use material in absolutely different forms. The bundling or baling machine calls for the long, flexible material, while the usual briquetting apparatus handles best the short, easily fed boring. The following is a comprehensive definition of briquetting: The process of fabricating small or fine materials, usually the breakage or wastage from larger blocks of the same nature, into large sizes more convenient for the purpose in hand, that purpose involving the destruction of the product or briquette, as such, either by useful consumption or as a step in a melting or reducing operation.

In the manufacture of metal briquettes for the melt, it is generally advisable that no binder be used unless the binding material is in the nature of a flux. Binders, however apparently harmless in themselves, too often introduce metallurgical complexities in the final product. In all metal briquetting it is considered desirable to achieve the desired results through the medium of pressure alone. When heavy, slow pressure is applied to metal particles or chips, a condition arises exactly analogous to the natural formation of sandstone or conglomerate rocks in nature. Rocks formed from sand and like fine material are of two sorts—those formed by pressure alone, and those cemented by a natural binding material, or chemical action. It is from the first variety that we draw our analogy. Fine materials, whether rock particles or metal chips, show characteristic strains under compression. In some cases but little pressure is necessary to obtain distortion and consequent flow. The malleable metals, notably lead, change shape under compression. The surfaces soften and adhere as particles of ice adhere when held together. This is a principle applying to but few types of metal or rock particles. Lead alloys and babbitt metals are consequently extremely easy to briquette. Copper, aluminum and their alloys, notably brass—and incidentally to a greater degree iron and steel—do not show great changes of shape under pressure other than simple bending. None the less, a strong cementing action takes place between the particles under pressure heretofore explained by the term "flow." After the preliminary packing pressure has been exerted, whereby the metallic units are interlocked or forced against each other and the included air has been slowly expelled, the building up to extreme pressures causes a new interrelation of the particles, a strong bond of adhesion, resulting in a briquette that is so strong, so homogeneous that it is frequently accepted as the metallurgical equivalent of heavy scrap. The little heat generated is insufficient to cause binding through the medium of melting. In the brasses, aluminum alloys and the like there is not the pressure flow characteristic of the more malleable metals—for even minute surface imperfections are not greatly affected. What, then, causes the bond, assuming that mere interlocking is insufficient?

Materials under strain are subject to what is known as "skin tension." Considering the outer layer of a metallic particle as the "skin," we may imagine it, under pressure, to be subjected to strains within and without which will cause alter-

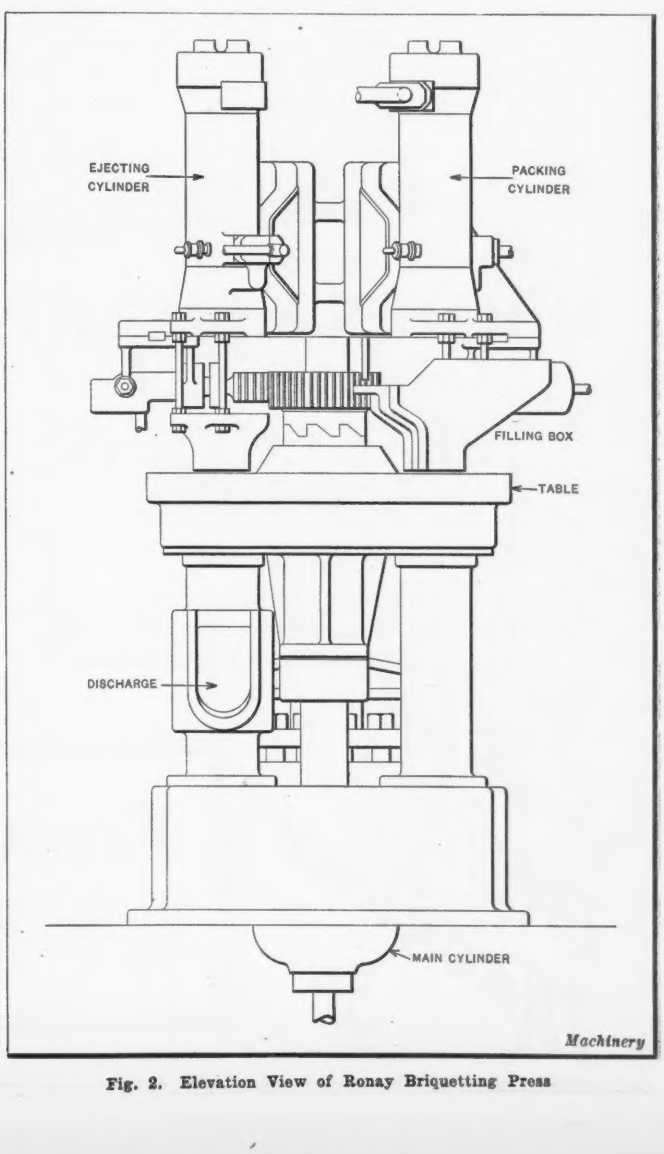
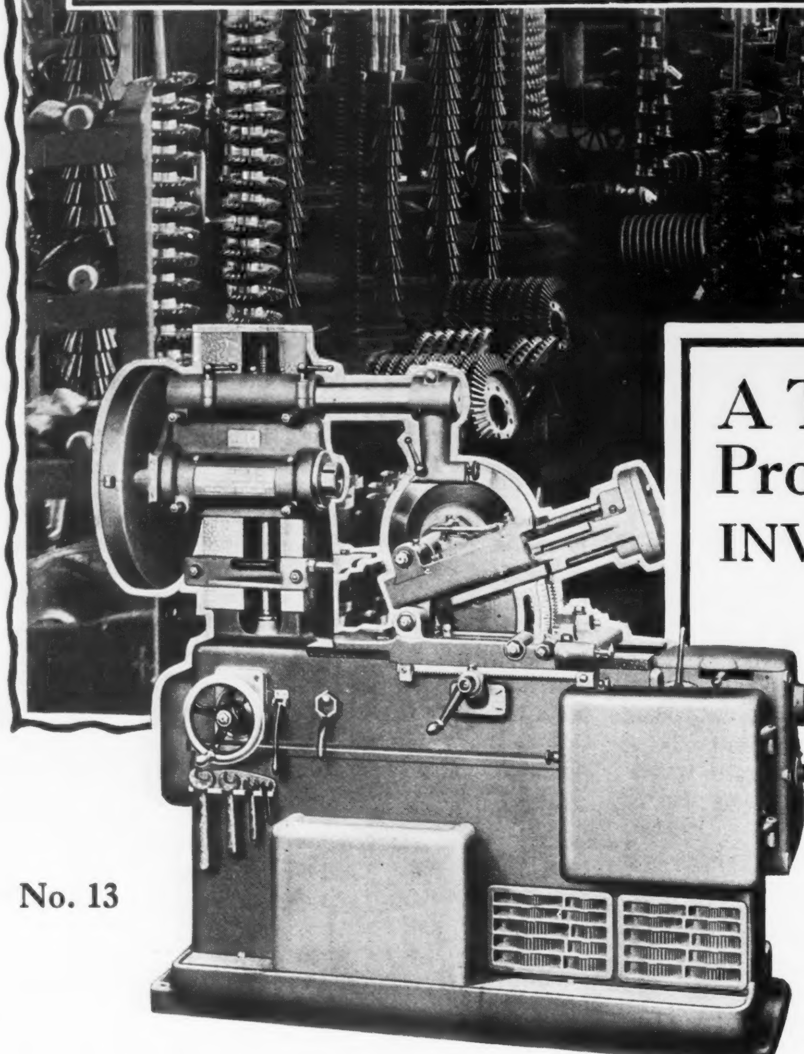


Fig. 2. Elevation View of Ronay Briquetting Press

[1]Abstract of an article by A. L. Stillman, published in the "Journal of the American Institute of Metals," September, 1917.

"Built to Stand the Steady Drive of the Busy Shop"



No. 13

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nating minute stretch and contraction, with or without fissility. Two such surfaces in contact will show a tendency to merge into each other. If microscopic cracks or fissures occur, it is reasonable to assume that the bonding action is heightened thereby. This "skin tension" is offered as an explanation of the bonding that unquestionably occurs without change of shape. It is not "flow," as such, but may be regarded as the preliminary symptom of flow. It is true that with very hard steels, and even some bronzes, the very high pressures today realized are insufficient to produce even the slight skin tension necessary for bond, and in these cases it is the practice to use a binding material to assist the action. In the case of hard bronze, milk of lime has proved satisfactory as an aid to briquette making.

Of first importance in the manufacture of metal briquettes is the expulsion of the air surrounding the loose chips. Sudden application of force, impact by hammer blow or explosion will not make briquettes suitable for melting, because the sudden force gives no opportunity for the escape of air. Briquettes have been made thus all to frequently in the past. They contain minute chambers of air under high compression. In melting, this air breaks out, rending and tearing, and the least damage to be expected is the reduction of the briquette to its original state, thereby forfeiting all the economy anticipated. An ordinary hydraulic press can be used to make successful briquettes provided it is operated slowly, to get rid of included air. The result is usually a sacrifice of capacity and consequent expense. The few who have attempted commercial briquetting in ordinary hydraulic presses are gradually abandoning it. Special design is necessary to obtain simultaneously high capacity and quality of product.

Some progressive firms have presses especially designed to handle their chips which are working satisfactorily. Latterly there has been a tendency to adopt foreign practice. In Europe the necessity for conserving resources has been a problem far more pressing than in the United States for a great many years. So far as study and investigation proceeded, the result may be said to be standard briquettes of all classes of metals which are daily quoted as a market commodity. The problem has been solved in many ways; but the most successful and indeed the one system originating abroad that has made a definite progress in this country is the Ronay process. Here the problems solved may be summarized as follows: The pressure is brought to the maximum commercially permissible—the capacity is high and the cost per ton extremely low. The illustrations show the large size vertical Ronay press manufactured by the General Briquetting Co., 25 Broad St., New York City, under the name "Type A." Briefly, it consists of six molds 5 or 6 inches in diameter set in the horizontal rotary table. This table is automatically rotated, one-sixth revolution between each operation. The operation is controlled by the automatic hydraulic valve gear. In the operation, three molds are simultaneously subjected to different operations while the other three are idle. The succeeding operation brings these three idle molds under the three pistons. Briquettes are turned out on every sixth revolution of the table. In the first sector the mold is filled by gravity from a filling hopper and subjected to the action of a hydraulic packing plunger working from above in the center of the hopper. Imagining the machine in operation immediately after the filling and packing is completed, one-sixth revolution of the table brings the mold to the idle position, where it waits the filling of the succeeding mold. This complete, another one-sixth revolution brings it to the heavy-pressure piston. The mold is directly under a stationary counter-plunger and over a sliding plunger operated by a hydraulic piston. Pressure is admitted by valve gear to the hydraulic piston, and the lower plunger is forced against the chips in the mold. Under compression the mold rises, thereby avoiding friction of the chips against its sides and causing the counter-plunger to exert a pressure practically equivalent to that of the lower plunger, causing compression of the chips on both sides. To prevent inclusion of air, a downward pressure is exerted against the mold by adjustment of counterweights to obtain a difference of pressure between upper and lower plungers whereby the contained air escapes from the top. The counterweights prevent too rapid rising of the mold and the maintenance of the proper differential of pressure. The counterpressure is regulated in accordance with the character of the material briquetted. The increase in hydraulic pressure is not continuous, as a slight decrease in pressure takes place with each stroke of the pump. Here the weight of the mold overcomes somewhat the frictional resistance and the mold recedes slightly. The lifting of the mold is, therefore, somewhat spasmodic, resulting in a movement like shaking, which facilitates the expulsion of the air from the material.

With the expulsion of the air the pressure is brought up to maximum, which in the five-inch molds amounts to 33,000 pounds per square inch. Pressure is held just long enough to insure a permanent set to the briquette, which is now completely formed. The pressure is removed and another one-sixth turn brings the mold to the idle position. Then another one-sixth turn brings the mold containing the finished briquette to the ejection plunger, which is also hydraulically operated. From this point, another one-sixth turn brings the empty mold to an idle position, preliminary to the next position, where, the revolution having been completed, it is again under the feeding hopper. It is seen that the three operations of feeding (with packing plunger), pressing and ejection take place simultaneously with three different molds, the other three being in intermediate positions awaiting the same operations.

This press is designed to turn out four briquettes per minute, and the table is designed to complete forty revolutions per hour. The question of tonnage capacity depends entirely upon the kind of material fed into the hopper. Loose, fluffy stuff is difficult to feed and considerable air space is left in the mold prior to the preliminary packing operation. Briquettes of this material are sometimes but 1/2 to 2 inches high. This condition, fortunately exceptionally rare, would bring the machine down to a little over a ton per hour. The finer material feeds more readily, and briquettes as heavy as forty pounds apiece can easily be made—representing a capacity of a little less than five tons per hour. In general, expressed in terms of brass, two tons per hour may be regarded as an extremely conservative estimate, and for aluminum it would, of course, be lower, due to its lightness.

The labor required depends upon the degree to which automatic operation is carried. If the material is fine and uniform, automatic feeding is practiced. Usually, however, one man is necessary to watch the feeding and operation of the machines. If a conveyor is installed, the delivery of finished briquettes is automatic; if not, another man is required to remove and pile the briquettes. A first-class mechanic should be able to give part time to this machine, but the entire time of a skilled artisan is not required. In general, the cost of briquetting by this process—everything included—is less than $1.50 per ton (somewhat more for aluminum). So far as repair expense is concerned, it is common experience for a press to run regularly for several years without repair other than the renewal of the dies, which is done about once every three months. This type of press is of such capacity that it is adapted particularly to the needs of the larger foundries and metal industries, the scrap dealers handling a large tonnage and custom plants where several interested parties unite on a single briquetting installation.

* * *

The Society of Automotive Engineers, which will meet in the Engineering Societies' Building in New York City, January 9 and 10, has selected for one of the topics of discussion "The Reasons behind the Liberty Engine," this discussion being scheduled for Thursday afternoon, January 10. Major Jesse G. Vincent, who was largely responsible for the design of the engine and who is now responsible for its development at the aviation headquarters in Dayton, Ohio, will present a special address, going into the reasons for the present twelve-cylinder Liberty engine, after which the discussion will be opened by Colonel Clark, who is chief in charge of aviation engineering in the Signal Corps. His phase of the discussion will deal with the military requirements of aviation engines. A number of other aviation experts will also take part in the discussion.

HEAT-TREATMENT OF AUTOMOBILE PARTS[1]

The art of improving steel by heat-treatment was known and used by a few men for quite a number of years, but it has been considered a commercial manufacturing possibility only in recent years. As the benefits and significance of heat-treatment became recognized, research and progress in all subjects closely allied with the treatment of steel were stimulated. The results of this stimulation were better furnaces to produce the steel, different steels, and many radical changes in the design of machine tools. We have only to go back fifteen or twenty years to realize what this progress has been. The writer can recall one time when a gear hob six inches in diameter and eight inches long had to be hardened. With the aid of a few firebricks, an oven was built in the coals in the smith's forge, which was in a dark corner of the shop, the hob was put into this oven, and the blast turned on. When the human pyrometer guessed that the hob was hot enough, it was pulled out and hung on a wire in the same air blast until cool. While we do not know a great deal more about the fundamental principles of heat-treating than our fathers did, more people know these principles, so that today there is a special kind of steel for almost every purpose.

Few men, other than the designing engineers, have any idea of the number of steels there are and the great variety of treatments these steels receive. For instance, in one automobile the wire-wheel hubs are drawn up from special, soft, deep-drawing low-carbon steel, and finally given a treatment to bring the steel to condition after drawing. Vanadium steel may be substituted for this deep-drawing steel before long. The wire-wheel spokes are a high-carbon steel drawn down with extra care and set up cold. The steering knuckle and arms are 0.28 to 0.35 per cent carbon, chrome-vanadium steel, and are treated to have about 105,000 pounds tensile strength. The knuckle ball cups and races are of 0.15 to 0.22 per cent carbon chrome-vanadium steel and are casehardened to about 75 on the scleroscope.

The front-axle forging is a straight 0.35 to 0.45 per cent carbon steel forging treated to a tensile strength of 100,000 pounds; the center of the beam is drawn back to 65,000 pounds. The ball studs in the knuckle arms are 0.15 to 0.25 per cent carbon chrome-nickel steel and are carburized. The cross-tie rod tube is a 0.25 to 0.35 per cent carbon 3.5 per cent nickel-steel tube and is heat-treated. The springs that fasten the axle to the frame are of 0.42 to 0.52 per cent carbon chrome-vanadium steel and are heat-treated. The frame itself is from hot-rolled sheets about 0.12 to 0.20 per cent carbon; special attention is given to sulphur and phosphorus to allow of cold pressing.

Practically all the levers, pedals and small brackets on the chassis are drop-forged from 0.25 to 0.35 per cent straight carbon steel and are heat-treated so as to have an average tensile strength of about 90,000 pounds. The motor shell is a steel casting of a special analysis and treatment that give it the magnetic properties; the armature core plates are punched from steel sheets especially produced for that purpose. The armature shaft is a 0.28 to 0.35 per cent carbon chrome-vanadium steel and is treated to have a tensile strength of 110,000 pounds. The universal joint forgings are of 0.25 to 0.35 per cent carbon, 3.5 per cent nickel steel, and are treated to have a tensile strength of 100,000 pounds; the pins for these joints are of 0.15 to 0.22 per cent carbon chrome-vanadium steel, casehardened.

The propeller shaft tube is especially swaged from 0.25 to 0.35 per cent carbon steel that contains 3.5 per cent nickel. This propeller shaft revolves inside an especially swaged torque tube made from Mayari 0.25 to 0.35 per cent carbon, 1.5 per cent nickel-chrome steel, and is connected with the pinion shaft, which is made of 0.15 to 0.22 per cent carbon, 5 per cent nickel electric steel, and is especially carburized with one tempering heat. This pinion drives the rear axle gear, which is made of 0.15 to 0.22 per cent carbon, 3.5 per cent nickel electric steel, and is especially carburized and tempered in a Gleason tempering machine. Inside this driving gear are the differential gears made from drop-forged 0.15 to 0.25 per cent carbon chrome nickel steel and carefully carburized. Exactly what is the strength of either the driving gear or the differential gears, it is impossible to say, owing to their shape, but destruction tests show them to possess enormous strength and the casehardening gives the spiral gears an almost indefinite life. The drive shafts from the differential to the hubs are of 0.42 to 0.52 per cent carbon chrome-vanadium steel, and are heat-treated to have a tensile strength from 160,000 to 180,000 pounds; the driving flanges at the hubs are of 0.25 to 0.35 per cent straight carbon steel and are heat-treated to have a tensile strength of about 100,000 pounds. The upper bracket, which connects the main spring with the chassis, is a 0.28 to 0.35 carbon chrome-vanadium steel forging that has been heat-treated to give a tensile strength of from 110,000 to 120,000 pounds. Even the irons that support the fenders are of 0.28 to 0.35 per cent chrome-vanadium heat-treated steel.

This list shows that there are many different alloy steels to be produced and treated for the manufacture of automobiles; and, in addition, there are many kinds of steel sheets finished in all conditions from dull black to extra bright and having a wide variation of deep drawing qualities. If the mills are required to produce this great variety of steels for the automobile trade only, how much more must they have to do to take care of the locomotive, rolling stock, rails, construction work, ammunitions, guns, armor plates, shipbuilding, electrical engineering, airplanes, and every other business using any form of steel? Many people tell us that the war in Europe will be won with airplanes, but, indirectly, heat-treating will win the war, for the success of the trucks, automobiles, air engines, guns, ammunition, etc., depend upon successful heat-treating of the steel used in the construction of these articles.

[1]Extract from an address delivered before the Steel Treating Research Society, of Chicago, Ill., by Arthur W. Medhurst, assistant general manager of the Anderson Electric Car Co., of Detroit, Mich.

PERSONALS

Sherwood H. Standish, formerly assistant superintendent of the Northwestern Malleable Iron Co., Milwaukee, Wis., has become associated with the Stowell Co., South Milwaukee, Wis., in the capacity of works manager.

Alfred D. Flinn has been appointed permanent secretary of the Engineering Council for the United Engineering Society and the Engineering Foundation, succeeding Calvert Townley, who has held office since the organization of the council.

George A. Rees has been appointed general purchasing agent of the Chicago Pneumatic Tool Co., with headquarters at 913 Fisher Bldg., Chicago, Ill. Mr. Rees succeeds R. S. Baker, who has found it necessary to devote his entire time to his official duties as auditor.

Daniel Willard, president of the Baltimore & Ohio Railroad and head of the advisory committee of the Council of National Defense, has been appointed chairman of the War Industries Board, succeeding Frank A. Scott, who recently resigned on account of ill health.

L. F. Hamilton, for several years in charge of the advertising department of the National Tube Co., Frick Bldg., Pittsburg, Pa., has resigned to become advertising manager of the Walworth Mfg. Co., of Boston, Mass. Mr. Hamilton is succeeded by W. L. Schaeffer.

A. N. Martin, industrial agent of the Baltimore & Ohio Railway Co. has resigned and taken the position of general sales manager for the Fulflo Pump Co., of Cincinnati, Ohio, manufacturer of small centrifugal pumps for machine tools, automobile motors, airplane motors, etc.

W. H. Harman, vice-president and general sales manager of the Southwark Foundry & Machine Co., Philadelphia, Pa., was elected president of that company on November 1, 1917, to fill the vacancy caused by the election of Robert Radford to the chairmanship of the board of directors.

J. H. Schneider, formerly with the Lodge & Shipley Machine Tool Co. and later assistant superintendent in charge of special organization and engineering work with the Gurney Electric Elevator Co., Honesdale, Pa., has been made head of the efficiency department of the American Tool Works Co., Cincinnati, Ohio.

Raymond G. Hutchinson, who has been division engineer of all branches of the American Brass Co. for several years, has been appointed superintendent of the Buffalo branch of the American Brass Co. in Buffalo, N. Y. This plant was formerly the Buffalo Copper & Brass Rolling Mill, and was acquired by the American Brass Co. last June.

E. W. Ames, manager of agencies of the American Steel Export Co., Woolworth Bldg., New York City, and A. G. Dowden, assistant purchasing agent of the company, sailed on November 30 en route for Japan. Together they will visit in the Far East, Japan, China, Philippine Islands and Straits Settlements. Mr. Ames will also go to India, Australia and New Zealand.

E. F. Lake, metallurgical engineer, formerly located in Detroit, Mich., has moved to 557 E. 50th Place, Chicago, Ill., and taken the position of assistant superintendent of the Rich Tool Co. The company is manufacturing one-piece valves from high-speed steel for airplane and automobile engines. It is also making valves from a high chromium steel similar to the stainless steel recently placed on the market.

George N. Peek, vice-president of Deere & Co., of Moline, Ill., has been appointed industrial representative of the War Industries Board. He will confer with manufacturers who have facilities for the production of munitions or other material required by the government or the Allies, and will select his own assistants subject to the approval of the chairman of the War Industries Board. This action creates, in effect, what has been forecasted as a Bureau of Manufacturing Resources.

J. C. Bannister has been made a vice-president of the Walworth Mfg. Co., Boston, Mass., manufacturer of iron pipe fittings, valves, Stillson wrenches, etc. Mr. Bannister has been connected with the manufacture of this type of product for twenty-six years, starting as foreman of the tapping department of the Haxtun Steam Heater Co., at Kewanee, in 1891. Mr. Bannister was made manager of the Kewanee Works when purchased by the National Tube Co., and continues in the same capacity under the present management.

Charles Piez, president of the Link-Belt Co., Chicago, has been appointed vice-president of the Emergency Fleet Corporation, Washington, D. C. Mr. Piez entered the employ of the Link-Belt Engineering Co. in Philadelphia immediately following graduation in 1889, as a draftsman, and with the growth of the company held successively the positions of chief engineer, general manager, and vice-president until 1906, when the Link-Belt Engineering Co. was merged with the two affiliated companies in the West, forming the Link-Belt Co., of which Mr. Piez was elected president.

John S. Myers, contributor to MACHINERY for many years, has left the employ of the Southwark Foundry & Machine Co., of Philadelphia, to take a position in the machinery fabrication department of the American International Shipbuilding Corporation, Philadelphia, Pa. Mr. Myers was one of the original force that helped to build the New York Shipbuilding Co.'s plant at Camden, N. J. He went to this job from the Chambersburg Engineering Co. Mr. Myers later had charge of the design of a general line of ship auxiliary machinery with the Williamson Bros. Co., now the American Engineering Co. For the past five years he has devoted most of his time to the design of steam turbines.

OBITUARIES

Henry Gaul, employed for many years by the Ajax Mfg. Co., Cleveland, Ohio, and widely known among the railroad, locomotive, car building and industrial forge departments as a resourceful and brilliant forging machine expert, died at his home in Cleveland, November 25, aged sixty-six years.

R. B. Dangeleisen, sales manager of the Globe Machine & Stamping Co., Cleveland, Ohio, died at Saranac Lake, N. Y., November 12, aged thirty-one years. He entered the employ of the company in 1902 and because of his efficiency and executive ability was advanced rapidly to the position that he held at the time of his death. He was conspicuously instrumental in developing the company's resources and facilities.

COMING EVENTS

January 14—Annual meeting of the American Institute of Consulting Engineers, New York City. F. A. Molitor, 35 Nassau St., New York City, secretary.

January 16-17—Convention of the American Society of Civil Engineers at the Engineering Societies Building, 29 W. 39th St., New York City. Charles Warren Hunt, secretary.

January 31—Monthly meeting of the Rochester Society of Technical Draftsmen, in Rooms 131-137, Sibley Block, 328 Main St., E., Rochester, N. Y. O. L. Angevine, Jr., secretary, 857 Genesee St., Rochester.

February 7-9—National Foreign Trade Council conference in Cincinnati, Ohio; Gibson Hotel, headquarters. Secretary, O. K. Davis, 1 Hanover Square, New York City.

April 24-25—Annual convention of the National Metal Trades Association at the Hotel Astor, New York City. Homer D. Sayre, secretary, 1021 Peoples Gas Bldg., Chicago, Ill.

May 15-17—Joint convention of the National Supply and Machinery Dealers' Association, Southern Supply and Machinery Dealers' Association and the American Supply and Machinery Manufacturers' Association in Cleveland, Ohio. Secretary of the American Supply and Machinery Manufacturers Association, F. D. Mitchell, Woolworth Bldg., New York City.

June 20-22—Fifth annual convention of the American Drop Forge Association held at the Iroquois Hotel, Buffalo, N. Y. E. B. Horne, "The American Drop Forger," 108 Smithfield St., Pittsburg, Pa., secretary.

NEW BOOKS AND PAMPHLETS

Operator's Handbook. 136 pages, 6 by 9¼ inches; 79 illustrations and diagrams, and 18 tables. Published by the Fellows Gear Shaper Co., Springfield, Vt.

This book gives adequate instructions for the setting up and operation of the Fellows spur and helical gear shapers, and the numerous illustrations make these instructions easily understood. It also deals with the care and maintenance of the shapers, sharpening the gear-cutters, cutting compounds, gaging and inspecting gears, etc. Rules, formulas and examples are given for calculating spur, internal and helical gears, as well as several tables of gear tooth parts.

Design of Splines and Clutch Teeth. 22 pages, 6 by 9 inches; 17 illustrations and diagrams. Published by the Fellows Gear Shaper Co., Springfield, Vt.

This pamphlet deals with the application of the involute curve in the production of splines and clutch teeth by the generating process. The features in favor of this application are accurate generation and duplication, making possible the manufacturing of strictly interchangeable parts, and also reducing the cost of manufacture. The pamphlet describes the use of this curve in connection with airplane, automobile and gun parts, electric starter shafts and couplings, and shrapnel and high-explosive shells.

Oxy-acetylene Welded Joints in Steel Plates. By Herbert F. Moore, 21 pages, 6 by 9 inches; illustrated. Published by the Engineering Experiment Station, University of Illinois, Urbana, Ill., as Bulletin No. 98. Price, ten cents.

The pamphlet records the result of a series of tests of oxy-acetylene welded joints in mild steel plates. For joints made with no subsequent treatment after welding, the joint efficiency for static tension was found to be about 100 per cent for plates one-half inch thick or less, and to decrease for thicker plates. For static tension tests, the efficiency of the material in the joints welded with no subsequent treatment was found to be not greater than 75 per cent. The joints were strengthened by working the metal after welding, and were weakened by annealing at 800 degrees C.

Our Army and Navy and How to Know Them. By Albert A. Hopkins. 124 pages, 4 by 5½ inches; illustrated. Published by Munn & Co., Woolworth Bldg., New York City. Price, 25 cents.

This little book is really two books in one; it is of pocket size, and thus is convenient for the soldier and sailor. The section on the U. S. Army is full of useful information in condensed form. The uniforms are described and the meanings of the various insignia. The location of the army ports, barracks, arsenals and cantonments, aviation camps and national guard tent camps are given, as well as a war map of the United States. The section on the U. S. Navy is quite similar in make-up and nature of contents. It treats on the naval reserve force, the naval militia, how to tell the rank of a naval officer, and contains a map showing the navy yards, etc.

United States Rifles and Machine Guns. By Fred H. Colvin and Ethan Viall. 332 pages, 9 by 12 inches; over 2300 illustrations. Published by the McGraw-Hill Book Co., Inc., 239 W. 39th St., New York City. Price, $3.

This book is a detailed account of the methods used in the manufacture of the Springfield 1903 model service rifle. The book is composed of reprinted pages from the "American Machinist" in which articles on the subject have been running for the past year. It goes into extreme detail, showing operations on all the component parts of the Springfield rifle. Brief chapters explaining the principal features of machine guns are also included. The book should be of value to men responsible for the design of tools and fixtures for making Springfield model rifles, and it is also likely that men engaged in the making of rifles of other models will find suggestions of value. It should be understood, however, that the work is specifically on the Springfield rifle and does not attempt to lay down general principles.

Kinematics of Machinery. By Arthur Warner Klein. 227 pages, 6 by 9 inches; numerous illustrations. Published by the McGraw-Hill Book Co., Inc., 239 W. 39th St., New York City. Price, $2.50.

This book is the outcome of many years of experience in teaching the subject of kinematics at the Lehigh University, where the author is professor of mechanical engineering. The book is especially intended as a text-book for use in engineering schools, and is believed to be particularly timely on account of the increasing attention that is given to this subject at the present time. The book is divided into eleven chapters, dealing with general principles; centrode construction; inversions; skeleton diagrams; displacement diagrams; velocity diagrams; special locus construction; kinematic analysis; acceleration determinations; governor gear accelerations; and force and mass reduction. Unfortunately, the book is not provided with any index, so that, while it may be excellent as a text-book, it cannot be used readily for general reference. In the last section of the book, the figure numbers do not follow consecutively, which also gives a peculiar appearance to the make-up.

MACHINERY'S Encyclopedia. Compiled and edited by Erik Oberg and Franklin D. Jones. Seven volumes, 8 by 11 inches; 3558 pages; 4634 illustrations. Published by The Industrial Press, New York City. Price, $36.

This encyclopedia is a work of reference covering practical mathematics and mechanics; machine design; machine construction and operation; electrical, gas, hydraulic and steam power machinery; metallurgy; and kindred subjects in the engineering field. There are articles on over 1200 different subjects, alphabetically arranged; in preparing this vast number of articles the editors were assisted by a large number of engineers, specialists in their respective fields, a list of seventy of the principal contributors and collaborators being given in conjunction with the preface in the first volume of the work. In addition, the editors have drawn upon all the sources of mechanical information available to them. Numerous articles have been abstracted and condensed from the volumes of MACHINERY, and hundreds of authorities on the leading engineering subjects were consulted. It was found, however, that there was a considerable number of mechanical subjects that had never been adequately treated in any existing work, and it became necessary for the editors to prepare treatises on many phases of machine design, construction and operation. The encyclopedia, therefore, is not merely a compilation in convenient form of mechanical data that had from time to time been published elsewhere, but contains a vast amount of original matter published here for the first time. This is true not only with regard to the subject of machine design and machine shop practice, but also in regard to the articles on electricity, all of which were specifically prepared for this work by electrical engineers of high standing and under the supervision of Eric A. Lof, engineer with the Power and Mining Engineering Department of the General Electric Co., who acted as special editor of the electrical departments. Throughout the work the practical side has always been given careful consideration, and the theory of any mechanical subject has been omitted when not necessary to make the subject intelligible or more easily comprehended. Academic discussions have been avoided. Some subjects have been dealt with briefly, either because the information relating to them constitutes common knowledge, or because they are comparatively unimportant. Other subjects, again, have been dealt with in great detail, either because of their particular importance to the field covered by the encyclopedia, or because they deal with newly developed fields upon which information is more difficult to obtain and upon which a complete treatise, therefore, is more valuable. The work is illustrated with line engravings made by the wax process, which permits an unusually clear and distinct presentation, and the typographical appearance has been pronounced unusually good, great care having been taken in selecting the proper kind of type, size of page, and general arrangement. The same kind of type, only of a larger size, as was used in MACHINERY'S Handbook, and which has been generally commended, is employed in this work.

NEW CATALOGUES AND CIRCULARS

Fred. C. Dickow, 33-35 S. DesPlaines St., Chicago, Ill. Circular of 10-inch index universal centers.

Ready Tool Co., Bridgeport, Conn. Circular advertising "Red-E" butt-welded and top-welded stellite tools.

Fulflo Pump Co., 126 Opera Place, Cincinnati, Ohio. Circular of the "Fulflo" centrifugal pump, for use on grinding machines.

J. A. Moller, 57 Lawton St., New Rochelle, N. Y. Circular of ball-bearing lathe centers, suitable for high-speed engine lathe work.

Nagle Corliss Engine Works, Erie, Pa. Bulletin 30 descriptive of Class Y-C-E duplex, direct-connected, electrically driven air compressors.

Weaver Mfg. Co., Springfield, Ill. Circular of Weaver garage equipment, including tire spreader, auto hoist, auto oiler, tire changer, twin jacks, etc.

Oliver Machinery Co., Grand Rapids, Mich. Circular descriptive of the Oliver No. 56 motor-driven speed lathe, using either direct- or alternating-current motors.

David A. Wright, 568 Washington Blvd., Chicago, Ill. Price list of the line of triple-geared Fifield engine lathes, which are built in sizes from 24 to 96 inches swing.

Wetmore Mechanical Laboratory Co., 605 Enterprise Bldg., Milwaukee, Wis. Circular of special taps, hobs, reamers, cutters and small tools for shell manufacturers.

Link-Belt Co., Chicago, Ill. Book 310, entitled "The Ideal Drive for Clayworking Machinery," illustrating the Link-Belt silent chain drive installed in a clayworking plant.

Kelly Reamer Co., Cleveland, Ohio. Catalogue G of Kelly production tools, including adjustable reamers and boring tools. The catalogue illustrates these tools in use and gives the actual production obtained with them.

Gisholt Machine Co., 1200 E. Washington Ave., Madison, Wis. Bulletin entitled "Standardizing in the Machine Shop," showing work performed on the Gisholt turret lathe with standard tools, and giving time for each case.

New Departure Mfg. Co., Bristol, Conn. Circulars 103 FE to 105 FE inclusive, illustrating New Departure ball bearing mounting in combination grinders, ball bearings in centrifugal pump, and ball bearings in small generator set.

Thompson Grinder Co., Springfield, Ohio. Circular of the Thompson 10- by 36-inch universal grinding machine, illustrating the machine arranged for cylindrical grinding, surface grinding, knife or edge grinding and internal grinding.

Bacharach Industrial Instrument Co., Pittsburg, Pa. Catalogue D, describing the design and construction of "Hydro" pressure and draft recorders and illustrating the different types of recorders as well as their application in various fields of industry.

Tate-Jones & Co., Inc., Pittsburg, Pa. Bulletin 160, on "Recuperative" gas oven furnaces, a line of furnaces for accurate temperature work for use in hardening carbon steel, preheating or reheating high-speed steels, annealing and hardening.

Terminal Machine Co., 30 Church St., New York City. Catalogue of new and used first-class machine tools, including drill presses, turret lathes, engine lathes, grinders, milling machines, planers, power presses, radial drilling machines, screw machines, shapers and tappers.

New Britain Machine Co., New Britain, Conn. Circular descriptive of New Britain drop-head polishing and buffing machines equipped with either plain or ball bearings. These machines are driven by belt from below, thus eliminating countershafts, idlers, loose pulleys, and shifting belts.

J. A. Moller, 57 Lawton St., New Rochelle, N. Y. Circular of the Moller shaper saw, which consists of a frame made in two sizes that is held in the tool-block of a shaper, thus converting an ordinary shaper into a powerful hacksaw machine. Frames are furnished for 14- and 18-inch blades.

Sundstrom Mfg. Co., 3201 Shields Ave., Chicago, Ill. Circular of the "Rex" die testing press, which is a simple bent hand press with slides, that is adapted for testing punches in dies when working them down to fit. The testing press may be also used for cutting blanks, setting dowel pins and as an arbor press.

Electric Furnace Co., Alliance, Ohio. Bulletin of the Baily automatic electric furnaces for the heat-treatment of high-explosive and shrapnel shells. The equipment provides for accurate temperature control and an automatic manipulating device by which the shells are charged into the furnace and quenched when heated to the required temperature.

Pratt & Whitney Co., Hartford, Conn., has through its welfare department begun the publication of a factory newspaper called "Bench and Board." The first number contains the biography of Jeremiah H. Coffey, who has been in the service of the Pratt & Whitney Co. fifty years, and who was one of five employes who recently received a cash bonus in gold for long service.

Taft-Peirce Mfg. Co., Woonsocket, R. I. Bulletin 101, describing in detail the construction of the Martell adjustable reamers and the uses to which they may be put. By the use of a gang of Martell reamers, it is possible to ream simultaneously any number of bearings in a machine to true size and in alignment that is correct within 0.00025 inch.

Metals Coating Co. of America, 100 Summer St., Boston, Mass. Circular of the Schoop metal spraying process by which finely divided metal is sprayed on the object to be coated, thus forming a metal protection similar to electroplating or galvanizing. The circular illustrates the application of the process to bridge work, gas ovens, objects of art, and shows the principle of the Schoop pistol.

Globe Machine & Stamping Co., 1250 W. 76th St., Cleveland, Ohio. Booklet entitled "Sherardizing—The Globe Way," discussing the subject of sherardizing and pointing out the value of this process of rustproofing. The booklet takes up the application of the sherardizing process to threaded material, castings, nails, rivets, etc., forgings, steel tubes or mandrels and piping, as well as other special work.

Globe Machine & Stamping Co., 1250 W. 76th St., Cleveland, Ohio. Catalogue entitled "The Globe Tumbling Book," illustrating and describing the various types of Globe tumbling and burnishing barrels. Some effective tumbling methods are also described. A separate price list is issued with the catalogue giving the prices of tilting tumbling barrels equipped with sheet steel, cast iron or wooden shells.

Norton Co., Worcester, Mass. Pamphlet entitled "Tool Grinding" applying to cutters, reamers, drills, taps, lathe and planer tools and dies. The pamphlet is 3½ by 6⅛ inches, and as it contains only forty pages, is of convenient pocket size. Machinists, toolmakers and others concerned with the maintenance of tools in use in metal-working will find much valuable material in this little treatise on tool grinding.

Ajax Metal Co., Frankford Ave. and Richmond St., Philadelphia, Pa. Circular of Ajax "Bull" babbitt, outlining the principles on which the formula for this babbitt is based. The advantages claimed for Ajax "Bull" babbitt are slow rate of wear, cool running at any speed, and low cost. It is adaptable for all general uses except where the pressure is very great or where it must sustain the shock of severe pounding.

Transmission Ball Bearing Co., Inc., Buffalo, N. Y. Catalogue 3 describing the Chapman type of ball bearings for transmission. The catalogue gives a formula for the load-carrying capacity of ball bearings, and reproduces power curves for different types of bearings. Apparatus for testing ball bearings is described and the results of comparative tests made on ordinary journal bearings and Chapman ball bearings are included.

Wilson Welder & Metals Co., Inc., Vanderbilt Ave. and 45th St., New York City. Catalogue entitled "Electric Welding," treating specifically of the Wilson System of welding, its scope and advantages. Specifications of the equipment are given, and results of tests on work welded by this system are included. The book is liberally illustrated with halftones, line cuts and blueprints, showing the equipment and examples of work done.

Langelier Mfg. Co., Providence, R. I. Catalogue of drilling and tapping machines for general manufacturing use, giving specifications for belt-driven plain-bearing pedestal drilling machines, belt-driven, plain-bearing bench drilling machines, belt-driven plain-bearing floor-type gang drilling machines, belt-driven plain-bearing bench gang drilling machines, motor-driven plain-bearing bench drilling machines, motor-driven plain-bearing pedestal drilling machines, single-spindle horizontal bench tapping machine with and without tailstock, and single-spindle vertical drilling and tapping machine made in bench and floor pedestal types.

New Britain Machine Co., New Britain, Conn. Catalogue of New Britain automatic multiple-spindle chucking machines, built in two types, the single-head for machining pieces which require operations on only one end, and the double-head for machining pieces which require operations on both ends. The catalogue gives specifications for the various sizes of these two types of machines and contains a detailed description of the work-holding devices and various parts. An interesting section of the book is that which shows illustrations of work done in New Britain automatics. Line drawings of the work are reproduced, and the descriptive matter specifies the material, operations performed and type and size of machine used.

Lefax, Inc., Sheridan Bldg., Philadelphia, Pa., is now publishing a number of sheets on military subjects as a part of its loose-leaf data sheet service. The sheets so far issued consist of digest of government publications on such subjects as the cleaning and care of rifles, semaphore and other forms of signaling, drill regulations, range tables, description and operation of rifles, principles and modern developments of trench warfare, and methods of estimating distances. The sheets are of uniform size, punched to fit the standard loose-leaf pocketbook, and are indexed on the same plan as the "Lefax" data sheets covering the various branches of engineering and general subjects.

Westinghouse Electric & Mfg. Co., East Pittsburg, Pa. Catalogue 30 on Westinghouse direct-current motors and generators, covering the company's complete line of direct-current motors and generators for industrial service. Several pages are given over to general information regarding the ordering, classification and selection of direct-current motors following which are description, rating and dimensions for Type SK commutating-pole motors; various modifications of Type SK elevator motors; reversing planer motor equipment; Type CD motors; headstock equipment for woodworking plants; Type SK and CD motor generators; and arc-welding equipment. Considerable information is given on arc welding, headstock equipment, motion-picture service and battery-charging service.

TRADE NOTES

Economy Drawing Table Co., has moved from Toledo, Ohio, to Adrian, Mich.

Springfield Grinding Co., Chester, Mass., will hereafter be known as the Maxf Grinding Wheel Corporation.

Biggs-Watterson Co. has removed its offices from the Guardian Building to 1235-1237 W. 9th St., Cleveland, Ohio.

United Bearings Co., formerly at 2033 Mapes Ave., Bronx, New York City, is now located at 63 Lincoln Blvd., Hempstead, L. I.

Driggs Mfg. Corporation, New Haven, Conn., has bought out the business of the New Haven Mfg. Co., and will continue to manufacture the New Haven lathes.

Craley Mfg. Co. has moved its factory from Mount Joy, Pa., to Lancaster, Pa., where increased facilities have been provided for making the locating fixture known as the "Master Toolmaker," which was described in the December number of MACHINERY.

Daniele Stussi, formerly Stussi & Zweifel, Milan, Italy, dealer in machine tools and woodworking machinery, announces that on account of the death of Frederich Zweifel, Mr. Daniele Stussi has become the exclusive proprietor of the firm, which will henceforth be conducted under the name Daniele Stussi.

Gorham & Goddard Co., 39 Congress St. W., Detroit, Mich., maker of standard and special milling cutters, announces that L. C. Gorham has retired and the corporation will hereafter be known as Goddard & Goddard Co. The president and general manager is Archibald N. Goddard and the treasurer is Dwight Goddard.

Greaves-Klusman Machine Tool Co., Cincinnati, Ohio, has acquired the plant of the Champion Tool Works Co. on Spring Grove Ave., Cincinnati, and will fit it up for the manufacture of the Greaves-Klusman lathes. The Champion Tool Works Co. has built a new plant at Winton Place, Cincinnati, which will be occupied in the near future.

Greenfield Tap & Die Corporation, Greenfield, Mass., has purchased the Bickford Machine Co. of Greenfield. It will be known hereafter as a division of the Greenfield Tap & Die Corporation. The Bickford Machine Co. has been in business for about ten years and has specialized in building milling machines, screw machines, special machinery for tap and twist drill manufacture, etc.

Excelsior Tool & Machine Co., 30th to 32nd Sts., Ridge to Jefferson Ave., East St. Louis, Ill., has made plans to extend its factory and add to its foundry building a steel extension, with brick and metal sash siding; also large core oven and ten-ton and two-ton electric cranes. The company will also erect a two-story fireproof pattern storage, pattern-shop, stock-room and garage building.

Fulflo Pump Co., 126 Opera Place, Cincinnati, Ohio, manufacturer of "Fulflo" pumps, has acquired five acres of ground at Blanchester, Ohio, on the main line of the Baltimore & Ohio Railroad, on which a two-story machine shop and foundry is being erected. The company expects to raise its production up to five hundred small centrifugal pumps per day by March 1, and to produce one thousand per day by midsummer.

Bridgeport Brass Co., Bridgeport, Conn., has instituted group insurance for its workers that includes in addition to life insurance, benefit for accidents and sickness along the lines of the compensation laws of some states. Under the company's plan any employe may receive half of his wages up to a certain maximum for a period not exceeding twenty-six weeks, for disability or sickness, and a maximum life insurance policy of $1000. The company has issued a pamphlet entitled "A Cooperative Plan of Benefits Covering Accidents, Sickness and Death."

Abell-Howe Co., 565 Washington Blvd., Chicago, Ill., has established branch offices at 30 Church St., New York City, in charge of J. R. Shays, Jr.; at 5086 Jenkins Arcade, Pittsburg, in charge of C. W. Wheeler and Wayne Paulin; and at 803 Ford Bldg., Detroit, Mich., in charge of H. G. Bates. The company is also represented in connection with the sale of Howe trucks at Boston by the Boston Steel & Mfg. Co., and in the Atlantic Coast states, Pittsburg and Cincinnati territory by the Howe Scale Co. and J. S. McCormick Co. In addition, it is represented in New England by the Watkins Engineering Supply Co., of Boston, and in the Northwest by Frank J. Rose Co., Minneapolis, Minn., for the sale of "American" high-speed chain.

Glidden Varnish Co., Cleveland, Ohio, and its subsidiary, the Glidden Varnish Co., Ltd., of Toronto, Canada, have been purchased by a newly formed corporation headed by Adrian D. Joyce, who was recently director and general manager of sales and distribution of the Sherwin-Williams Co. The new company will be known as the Glidden Co., and will have a capitalization of $2,500,000, fully paid in. Members of the Glidden family, including F. A. Glidden, president of the Glidden Varnish Co., will retire. The officers of the new corporation will be Adrian D. Joyce, president; O. A. Hasse, vice-president; and R. H. Horsburgh, secretary-treasurer. The present Glidden plant occupies nearly seventeen acres and is a model in completeness of equipment and modern arrangement.